EAPCET (AM)

BOTANY

CENTRE FOR EDUCATIONAL DEVELOPMENT OF MINORITIES
Osmania University
Minorities Welfare Department, Govt. of Telangana
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By

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Lecturer In Life Sciences And Competitive Exams

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PREFACE

Taking competitive examinations has became the order of the day for any educated young man who is desirous of seeking any coveted job, a seat in any prestigious college. The approach required for such competitive examination is different from that of taking an academic examination.

It was observed that most of the minority candidates do not fare well at these competitive examinations not because they lack in talents but because they can neither afford to join the private coaching centres nor could purchase the required study material.

In order to improve the participation and performance of the candidates belonging to minorities in such competitive examinations, the Minorities Welfare Department, State Government sponsored a project to Osmania University. The University in turn established Centre for Educational Development of Minorities (CEDM) in 1994 in Nizam College. Since then, the Centre has been offering free coaching for the benefit of candidates belonging to minority communities appearing for various job seeking and admission seeking competitive examinations at Hyderabad and other minority concentrated districts of the state. In respect of job-seeking examinations, the Centre is providing free coaching and study material for TS TRT, TS TET etc. and for admission oriented examinations such as NEET, EAPCET, ICET, ECET, EdCET, DEECET and POLYCET etc. In addition to these coaching programmes, the Centre is also providing free coaching and study material to X class Urdu medium minority students in minority concentrated districts of the state to strengthen their educational foundation and to improve their performance in SSC Public Examination.

We wish to place on record the pains the compilers have taken to summarize and arrange the important questions. The Centre gratefully acknowledges their services.

If these study materials are of any help to the candidates, we feel immensely rewarded for the humble efforts we have put in.

Hyderabad
April 2024

Prof. S. A. Shukoor,
DIRECTOR

Content

First Year

Second Year

UNIT -I
DIVERSITY IN LIVING WORLD

THE LIVING WORLD

- Biology (or) Natural Science: It deals with the study of living organisms (Greek Bios = life, logos, doscourse or science)
- Founder of Biology: Aristotle
- The word Biology was first used by Lamarck
- Biology helps us to understand morphology, physiology, reproduction, variations, evolution, geographical distribution and other aspects related to living organisms
- Living organisms from Non living is distinguished by Claud Bernard
- The science related to plant is Botany. In Greek language the term 'Bous' means cattle and 'Bouskein' means 'cattle feed' Bouskein in course of time, 'Botane'
- Compound microscope helped in the detection of cell organelles
- Electron microscope helped in the study of ultrastructure of cell and cell organelles
- Ultra centrifuge helped in isolating the cell organelles
- Chromatographic techniques made it possible to separate the chemical compounds present in cell
- Egyptians and Assyrians – Recorded the information of crop plants and fruit trees in the form of Heiroglyphics
- A tharvana Veda describes about Medicinal plants
- The most ancient book about agriculture with a note on weeds – Krishi parasaram or Krishi sangraram
- The book which describes about 14 types of forest, the internal and external features of plants is Vrikshayurveda
- Parasara wrote Krishi parasaram and Vrishayurveda
- Greek philosophers like Socrates, Plato and Aristotle were responsible for the development of Botany
- Theophrastus is regarded as 'The Father of Botany'
- 'Historia plantarum' that includes the description of 500 plants with external and internal characters was written by Theophrastus
- The book that discussed plant soil relationship and the physiological activities of plants was written by Theophrastus
- Pling and Elder described about thousands of Medicinal plants

<u>IMPORTANT INFORMATION TO BE REMEMBER IN PLANT KINGDOM</u>:

- Tallest Living tree $\rightarrow$ Sequoia Semper Virens (Gymnosperm) (or) Father of the forest
- Tallest Angiosperm $\rightarrow$ Eucalyptus regnans
- Smallest angiosperm $\rightarrow$ Wolffia globosa
- Largest Fern (or) Pteridophyte $\rightarrow$ Alsophila excelsa
- Smallest Fern (or) Pteridophyte $\rightarrow$ Azolla
- Largest Cactus $\rightarrow$ Carnegia gigantium
- Largest Bryophyte $\rightarrow$ Dowsonia

- Smallest Bryophyte → Zoopsis
- Largest alga (seaweed) → Macrocystis pyrifera
- Smallest alga →Micromonas pusilla
- Smallest angiospermic parasite → Arceuthobium
- Largest Bacteria (spherical) → Thiomargarita namibiensis
- Smallest Bacteria → Pasteurella
- Largest Virus → Citrus tristeza Virus (or) Vaccina virus
- Smallest Virus → Tobacco Necrosis virus (or) Bacteriophage f_2
- Largest vegetative bud → Cabbage
- Rootless angiosperm → Utricularia
- Shootless angiosperm → Taeniophyllum, Monotropa
- Largest Simple Leaf → Victoria regia
  (or) Largest Hydrophytic leaf
- Largest inflorescence → Puya raimondi
  Agave americana
- Smallest inflorescence → Lemma
- Largest flower → Rafflesia arnoldi
- Smallest flower → Wolffia
- Largest fruit → Citrulus lanatur (water melon)
- Largest ovule → Cycas
- Largest egg → Cycas
- Largest spermatozoids → Cycas
- Longest style → Maize
- Largest seed → Lodoicea maldivica
- Largest seed → Orchids
- Heaviest wood → Olea laurifolia
- Lightest wood → Aeschynomene hispida
- Largest plant cell → Acetabularia
- Smallest cell → Mycoplasma gallisepticum or PPLO
- Largest angiospermic family → Asteraceae
- Largest Botanical garden in the world → The Royal Botanic garden,
  Kew, England
- The largest Botanical garden in India → Indian Botanic garden, Calcutta
- Largest Herabarium in the world → The Royal Botanic garden, Kew, England
- Largest Herbarium in India → Central National Herbarium, Sibpur, Howrah
- Religious tree of Hindus → Ficus religiosa
- State tree of A.P → Azadarachta indica (Neem)
- National fruit of India → Mangifera indica (Mango)
- National flower of India → Nelumbo nucite (Lotus)
- The pride fruit of India → Mango
- Least number of Chromosomes → Haplopappus gracilis (2n = 4)
- Highest number of Chromosomes → Ophioglossum (2n = 1260)
- Longest plant Chromosomes → Trillim (30μ)
- Most poisonous tungus → Amanita phalloids
- Angiospermic saprophyte → Monotropa
- Enucleate plant cell → Seive cells, Seive tube
- Dangerous weed in A.P → Parthenium bysterophorus

- Tallest grass → Phragmites communis
- Smallest grass → Mibora minima
- Cricket stumps & bails → Grewia tiliaefolia
- Cricket bats → Salix wood (willow plant)
- Handle of Hockey Stick → Salix wood
- Traveller’s Palm →Ravenela madagas – carensis
- Father of forest → Sequoia dendron gigantia
- Yesterday, today, tomorrow → Brunfelsa hopeana
- Golden age of Pteridophytes and Gymnosperms → Mesozoic era
- Vessel less angiosperms → Trocho dendron, Tetra centron Drimys
- Connecting link between living and non living → Virus
- Connecting line between plants & animals → Euglena
- Angiosperm which lack cotyledons → Cuscuta

DISCOVERIES

	Year
• Cell → Robert Hooke	1665
• Plasmamembrane Cell → W.Pfeffer	1890
• E.R. → K.R. Porter et al	1945
• Microsomes → Claude	1944
• Ribosomes → Palade	1955
• Golgi Complex → Camillo Golgi	1898
• Chloroplast → Sachs	1865
• Thylakoid → Menke	1962
• Quantasomes → Park & Beggins	1961
• Mitochondrion → Kollicker	1880
• Cristae → Palade	1952
• Oxysome → Ferndez Moran	1962
• Peroxisomes → Rhodin	1954
• Lysosome → Christian de Duve	1955
• Glyoxysomes → Beevers	1961
• Microtubules → De Robertis et al	1953
• tRNA → Zamecnik et al	1951
• mRNA → Jacob & Monod	1961
• Nucleus → Robert Brown	1831
• Chromosome → Hofmeister	1849
• Polytene Chromosome → Balbiani (Giant chromosome)	1881
• Nuclei acid → Friedrich Miescher	1869
• DNA polymerase I → Arthur Kornberg	1959
• Polynucleotide → S.Ochoa et al Phosphorylase	1956
• Genetic code → Nuremberg, H.G. Khorana et al	1961
• Amitosis →Robert Remark	1841
• Mitosis in plants → Strassburger	1875
• Meiosis →Strassburger	
• Sieve tube → Hartig	1837

- Double fertilization →Nawschin 1898
- Syngamy → Strassburger 1884
- Polyembryony →Leeuwenhoek 1719
- Mutations → Hugo de Vries 1901
- Induced mutation →J.J.Muller 1927
- Cytoplasmatic inheritance →Sonnehorn
- Artificial gene synthesis →H.G.Khorana 1969
- Transposons →Barbara Mc Clintock 1983
- Chlorophyll → P.Caventov 1817
- Auxin (IAA) →Kogl.Hagensmith 1933
- Gibberellins →Yabuta, Sumiki, Hayashi 1938
- Cytokinins →Skoog & Miller 1954
- Phytochrome →Butler et al 1959
- Operon →Jacob & Monod 1965
- Osmosis →Nollet
- ATP →K.Lohman 1919
- Photoperiodism →Garner & Allard 1920
- Penicillin →Alexander. Fleming 1929
- Streptomycin →Waksman 1945
- Heterothallism →Blakeslee 1904
- Bacteria →Leeuwenhoek 1676
- Plasmid→Jacob & Wollman 1965
- Bacterial Transformation →Griffith 1928
- Bacterial Conjugation→lederberg & Tatum 1946
- Bacterial Transduction →Zinder & Lenderberg 1953
- Viruses →Ivanowski 1892
- Bacteriophage→Twort & d'Herelle 1915
- Cyanophage→ Saffarman & Moris 1963
- Alternation of generations →Hofmeister 1851
- Spirogyra →Link 1820
- Rhizopus →Ehrenberg 1820
- Yellow fever →Walter Reed 1901
- Mitochondria in plant cell →Meves 1904
- Trisomics →Blakeslee 1920
- Fertilization in Angiosperms →Strassburger 1884
- Pollen tube in ovary →Amici 1830
- X –rays on mutations →Muller 1927
- Zymase → Buchner 1897
- Reverse transcriptase →Temin
- Rafflesia arnoldi →Sir Stamford Raffles 1818
- Concept of Plasmolysis →de Vries
- DNA in mitochondria →Nass 1963

Scientist	**Instrument**
Zanharias Janssen & H.Janssen (1590)	First Microscope
Leeuwen hoek (1632)	Simple Microscope
Robert Hooke (1665)	First C.Microscope

- Wilson (1710) Light C.Microscope
- Z.sigmonds (1900) Ultra Microscope
- Knoll & Ruska (1932) Electron Microscope
- Zernike (1935) Phase Contrast Microscope
- Von Ardenne (1938) Scanning E Microscope
- Burels (1943) Reflecting Microscope
- Coons (1945) Flourescence Microscope
- T.Stedberg Ultra Centrifugation

Instruments

- Manometer - To demonstrate root pressure
- Photometers -To demonstrate transpiration rate
- Willmonts bubbler -To measure the rate of Photosynthesis
- Kuhne's Vessel - To demonstrate fermentation
- Respiroscope - To Measure R.Q
- Auxanometers - To Measure growth

Experiments

Experiment	Aim
Thistle Funnel Experiment	To demonstrate Osmosis
Potato Osmoscope	To demonstrate Osmosis
Bell jar Experiment	To demonstrate Transpiration
Ringing Experiment	To demonstrate Ascent of Sap
Cobalt Chloride Experiment	To demonstrate Cuticular transpiration
Ganong's light screen Experiment	To demonstrate light is necessary for photosynthesis
Variegated leaf Experiment	To demonstrate chlorophyll is necessary for Photosynthesis
Molls half leaf Experiment	To demonstrate CO_2 is necessary for Photosynthesis
Hydrilla Funnel Experiment	To demonstrate O_2 is liberated dasing photosynthesis

Important Book and their Authors:

- Historia Plantarum - Theophrastus
- De Causis Plantarum – Theophrastus
- Enquiry into Plants - Theophrastus
- Micrographia - Robert Hooke
- Genera Plantarum - Bentham & Hooker
- Systema Naturae - Linnaeus
- Species Plantarum - Linnaeus
- Families of flowering plant - John Hutchinson
- Flora of British India - J.D Hookes
- Flora of Madras - G.S Gamble
- Flora of India - W.Roxburgh
- Origin of Species - Charles Darwin
- An introduction to the - P.Maheshwari

Embryology of Angiosperus

- Recent trendsin Embryology - P.Maheshwari
  of Angiosperus

Some important Scientists and their contributions:

Year	Name	Contribution
1802	Camarck & Treviranus	Proposed the term Biology
1780	Fontana	Observed Nucleolus
1828	Robert Brown	Brownian movement of Protoplasm
1844	Von Mohl	Importance of Protoplasm
1868	T.H Huxley	Protoplasm as the Physical basis of life
1921	C.B Bridges	Chromosomal aberration
1924	Feulgen & Rossenbeck	DNA staining
1930	Feulgen	RNA in cells
1944	Avery Macleod, Mc.Carty	DNA as heuditary Material
1974	Claude & Palade	Ultra structure of cell
1908	Juel & Murbelk	Pasthenogenesis
1541 - 1631	Gaspaed Bauhin	Idea of Binomial nomenclature
1969	Delbruck, Hershey	Virus reproduction
1970	H.G. Khorana	Synthesiud an aertifical gene
1727	Stephan Hales	Coined the term Root pretence
1915	R.M. Willstatter	Structure of chlorophyll
1926	F.W Went	Work on Auxius
1761	J.Koelreuttes	Hybridlagous (or) Heterosis

Important Dates

- 21st March – World Forest Day
- 5th June - World Environment Day
- 6th October – World Food Day
- 23rd December – World Farmer's Day (or) Kisan Divas

Theory / Hypothesis / Concept	Proposed by
1) Cell theory	M.J Schleiden (1838)
2) Cell lineage theory	R.Virchow (1839)
3) Protoplasm theory	Max Schulte & O.Hestwing (1861)
4) Chromosome theory	Sutton & Boveri (1902)
5) Gene theory	T.H Morgan (1933)
6) Germplasm theory	Weismann (1892)
7) Inheritance of Acquired characters	Lamarck (1809)
8) Mutation theory	Hugo de Vries (1901)
9) Natural selection	Charles Darwin (1859)
10) One gene - one enzyme hypotnuis	Beadle & Tatum (1941)
11) One gene – one Polypeptide hypothesis	V.M Ingram (1956)

12) Laws of Heredity	G.J Mendel (1866)
13) Gene Concept	Benzes
14) Apocalcell theory	Hotmeister (1857)
15) Histogen theory	Hanstein (1868)
16) Criteria of Essentiality of elements	Arnon & Scout (1939)
17) Donnan equilibrium theory	F.G Donnan (1911)
18) Root Pressure theory	Stephen Hales (1725)
19) Cohension Tension theory	Dixon & Bolly (1894)
20) Cock & key Mechanism	Emil fishes, DD.wood & Paul Fildes (1898)
21) Induced Fit theory	Koshland
22) Cacuin cycle	
23) Protoplasmic streaming	Melvin Calometal (1870)
24) Protoplasmic streaming	Hugo de Vries (1885)
25) C_4 Cycle	Hatch & Slake (1966)
26) Law of Limiting factors	F.F Blackman (1905)
27) E.M.P path way (Glycolysis)	Embden, Meyerholf & Pavaas
28) Kreb's cycle / Cilricacid cycle TCA cycle	Sir Hans Kreb (1943)
29) Chemi Osmotic theory	Mitchel
30) Carrier concept	Van Den Honest (1937)
31) Operon Concept	Jacob & Monod (1961)
32) Heterosis	G.H shull (1914)
33) Stelar theory	Van Teigham & Doulot
34) Cell division	Strass burger (1880)
35) Polyploidy	Lutz (1912)
36) Transpiration is necessary evil	Curtis (1926)

Model / Methods	**For**	**Proposers**
1) Trimellar model	Plasma membrane	Danial & Davson 1935
2) Fluid Mosaic model	Plasma membrane	Singer & Nicolson 1972
3) Folded Fibre model	Chromosome	Dupraw 1965
4) Double helix model	DNA	Watson & Orick 1953
5) Nucleosome model	Repeating units of chromatin	Kornberg 1979
6) Semi conservative model	DNA Replication	Watson & Crick 1953
7) Clver leaf model	t RNA	R.Holley 1965
8) L – Model	t RNA	S.H Kimetal 1972
9) Operon model	Gene regulatin	Jacob & Mond 1981
10) Z – model	DNA	Wang

Vegetable	**Morphology of the useful part**
• Carrot, Radish	Root
• Beet root, Turnip	Root
• Potato	Stem tuber
• Knol Khol	Tuberous stem
• Cabbage	Vegetative bud (Jerminal bud)
• Cauliflower	Inflorescence

• Onion	Bulb
• Colocasia	Corm
• Amorphophallus	Corm
• Peas, Beans	Immature pods, seeds
• Amaranthus	Leaves
• Hibiscus cannabinus	Leaves
• Tomato, cucumber	Fruit
• Brinjal	Fruit
• Banana	Green Fruit

PLANT PRODUCTS OF USE

PRODUCT	OBTAINED FROM
• Coffee powder	Perisperm (seeds) of coffee arabica
• Tea powder	Apices of camellia chinensis
• Coconut oil	Endosperm of Cocos nucifera
• Sesam oil	Seeds of Sesamum indicum
• Mustard oil	Seeds of Brassica Juncea b.nigra
• Groundnut oil	Seeds of Arachis hypogea
• Lavender oil	Lavendula vera
• Rosemary oil	Rosemarinus
• Colchicine	Corm of Colchicum autumnale
• Indigo dye	Indigofera tinctoria
• Haematoxylin	Haematoxylon compechianum (Log wood)
• Opium	Latex from immature fruits of Papaver Somniferum
• Quinine	Bark of Cinchona officinalis
• Assafoetida	Roots of Ferula asafoetida
• Sugar	Cane juice of Saccharum officinarum
• Cigarette	Cured leaves of Nicotiana tabaccum
• Peppermint	Mentha piperita
• Indian rubber Assam rubber	Latex of Ficus elastica
• Para rubber	Latex of Hevea brasiliensis
• Russian rubber	Taraxacum Koksaghyz
• Sandal wood	Santalum album
• Tamarind	Mesocarp of Tamarindus indica
• Agar – Agar	Red algae Ex: Gracillaria, Gelidium
• Iodine	Kelp of Brown algae (Laminaria)
• Alginates	Algae
• Rifle parts	Wood of walnut (Juglans sp)
• Hockey sticks (Blade)	Wood of Morus alba
• Hockey sticks (Handle)	Wood of Salix
• Cricket bats	Wood of Salix alba
• Cricket stumps and bails	Grewia tiliaefolia
• Railway sleepers	Wood of Cedrus deodara
• Bottle cork	Quercus suber

SCIENTIST	FIELD
• Aristotle	Father of Biology
• Theophrastus	Father of Botany
• F.E.Fritch / G.Klebs	Father of Phycology
• Micheli	Father of Mycology
• de Bary	Father of Modern Mycology
• Leeuwenhoek	Father of Bacteriology
• R.Koch	Father of Medical Bacterioilogy
• Louis Pasteur	Father of Micro Biology
• Robert Mayer	Father of Virology
• Robert Hooke	Father of Cytology
• G.J.Mendel	Father of Genetics
• T.H.Morgan	Father of Modern Genetics
• Charles Darwin	Father of Evolution
• Stephen Hales	Father of Plant Physiology
• Norman E Borlaug	Father of Green Revolution
• Hippocrates	Father of Medicine
• Leeuwenhoek	Father of Microscopy
• Thomas Fair Child	Father of Plant breeding
• Muller, Stalder	Father of Mutation breeding
• Schwann	Father of Cellular theory
• Schubler	Father of Edaphology/ Pedology
• Buchner	Father of Enzymology
• Millardet	Father of Fungicide technology
• John Lindley	Father of Horticulture
• Edward Jenner	Father of Immunology
• Haberlandt	Father of Tissue culture
• Adolph Brongniart	Father of Palaeobotany
• C.F. Wolff	Father of Plant Embryology
• de Candolle	Father of the study of crop plant evolution
• William Roxburgh	Father of Indian Botany

IMPORTANT DISCOVERIES

• Cell	Robert Hooke (1665)
• Free living cell	Anton Von Leeuwenhock
• Cell wall	Robert Hooke
• Plasma membrane	W.Pfeffer
• Nucleus	Robert Brown
• Nucleolus	Fontana
• Endoplasmic reticulum	K.R.Poter (1945)
• Microsomes	Claude
• Ribosomes	Palade
• Golgi complex	Camello Golgi

• Chloroplast	Sachs
• Mitochondria	Kolliker
• Mesosomes	Fitz – James
• Oxisomes	Fernandez – Moran
• Cytochromes	Mc Munn
• ATP	Lohmann
• Lysosomes	Christian de Duve
• Peroxisomes	Tolbert
• Glyoxysomes	Beevers, Brindenbach
• Sphaerosomes	Hanstein
• Microtubules	Ledbetter & Porter
• Quantasome	Park & Biggins
• Cristae	Palade

COMMON NAMES AND BOTANICAL NAMES

• Sweet William	Dianthus barbatus
• China rose	Hibiscus rosa – sinensis
• Candy tuft	Iberis amara
• Snapdragon	Antirrhinum majus
• Marigold	Tagetes erecta
• Flame of the forest or parrot tree	Butea monosperma
• Soy bean	Glycine max
• Safflower	Carthamus tinctorius
• Duck weed	Lemna
• Indian telegraph plant	Desmodium gyrans
• Areca nut	Areca catecha
• Walnut	Juglans regia
• Water chestnut	Trapa natans
• Water lettuce	Pistia stratiotes
• 4^0 clock plant	Mirabilis jalopa
• Shepherd's purse	Capsella bursa – pastoris
• Brussel's sprout	Brassica olearacea var.gemnifera
• Lettuce	Lactuca sativa
• Congress grass	Parthenium hysterophorus
• Red saunders or red sandal wood	Pterocarpus santalinus
• Century plant	Agave americana
• Evening primrose	Oenothera lamarkiana
• Ceara rubber plant	Manihot glaziovi
• Egg plant or bringal	Solanum melongena
• Traveller's palm	Ravenala madagascariensis
• Coral tree	Erythrina indica
• Sal wood tree	Shorea robusta
• Indian pipe plant	Monotropa
• 'Touch me not'	Mimosa pudica

or (Lajwanti)

• Forget me not	Tragia involucrata
• Custard apple	Annona sqamosa
• Straw berry	Fragaria vesca
• Night Queen	Cestrum nocturnum
• Red pepper or chilly	Capsicum annuum
• Lady's finger	Abelmoschus esculentus
• Holly hock	Althea rosea
• Cow pea	Vigna sinensis
• Litchi	Nephalium litchi
• Indigo (Blue dye)	Indigofera tinctoria
• Elephant apple	Feronia limonia
• Sweet orange	Citrus sinensis
• Lime	Citrus limon
• Alfalfa	Medicago somniferum
• Opium poppy	Papaver somniferum
• Almond	Prunus amygdalus
• Peach	Prunus persica
• Raspberry	Rubus idaeus
• Cork oak	Quercus suber
• Black pepper	Piper nigrum
• Oleander	Nerium oleander
• Mulberry	Morus alba
• Saffron	Crocus sativus
• Pine apple	Ananas sativus
• Cashew nut	Anacardium occidentale
• Wine grape	Vitis vinifera
• Papaw or papaya	Carica papaya
• Pomegranate	Punica granatum
• Guava	Psidium guajava
• Asafoetida	Ferula assafoetida
• Pepperment	Mentha piperata
• Pumpkin	Cucurbita pepo
• Water melon	Citrullus vulgaris
• Cucumber	Cucumis sativus
• Bitter gourd	Momordica charantia
• Bottle brush	Callistemon
• Tapioca, cassava	Manihot utilissima
• Castor	Ricinus communis
• Sugar cane	Saccharum
• Screw pine	Pandanus
• Sandal wood	Santalum album
• Dodder	Cuscuta
• Broomrape	Orobanche
• Mistie toe	Viscum
• Water hyacinth	Eichhornia
• Prickly pear	Opuntia

• Oil palm	Elaeis guinensis
• Deodar	Cedrus deodara
• Californian red wood	Sequioa sempervirens
• Sago palm	Cycas revoluta
• Spike moss or little club moss	Selaginella
• Royal fern	Osmunda
• Walking fern or Maiden hair fern	Adiantum
• Horse tail	Equisetum
• Horn wort (Common)	Anthoceros
• Fire moss or cord moss	Funaria
• Bog moss or Peat moss	Sphagnum
• Ergot	Calviceps pupurea
• Cup fungus	Peziza
• Red mould	Neurospora
• Blue/ green mould	Penicillium
• Bread mould	Rhizopus
• Sea palm	Posteisia
• The gulf weed	Sargassum
• Frog spawn alga	Batrachospermum
• Sea lettuce	Ulva
• Birch	Betula pubescence
• Sycamore	Acer pseudoplatanus
• Willow	Salix purpurea
• Canary grass	Phalaris canariensis
• Carnation	Dianthus caryophyliata

BOTANICAL NATIONAL INSTITUTES

1. **BSI**: Botanical Survey of India
    1. It was established by J.D.Hooker at Calcutta.
    2. The research centers are at Coimbatore, Pune, Shillong, Dehradun.
    3. The main function is to explore plant resources of our country by systematic survey.
    4. It preserves the herbarium of our country.
2. **IARI**: Indian Agriculture Research Institute
    1. This institute was established by Lord Curzon in 1905 at Pusa (North Bihar) under the name of Imperial Agricultural Research Institute.
    2. In 1936 it was shifted to Delhi and after independence its name is changed as Indian Agricultural Research Institute
    3. It provides post graduate training courses in Agriculture
    4. It has research centers where Agricultural Scientists carry research work.
    5. It has developed high yielding varieties of crop plants Jowar, Bajra, Maize, Wheat, Red gram etc.,
3. **CIMAP**: Central Institute of Medicinal and Aromatic plants
    1. It is located at Lucknow

2. The field stations are at Banglore, Jammu and Srinagar, Kodikanal, Panth Nagar
3. It is concerned with the cultivation and processing of medicinal and aromatic plants of our country
4. It encourages and promotes the cultivation of medicinally important plant by providing financial help
5. It develops new varieties of medicinal plants
6. It maintains the herbarium of medicinal plants of our country

4. **FRI**: Forest Research Institute
    1. It is located at Dehradun
    2. It carries research work on silviculture and forestry
    3. It advices the Government on matters relating the utilization of forest products
    4. It trains forest officers and rangers
5. **CSIR**: Council of Scientific & Industrial Research
    1. It is located at Delhi
    2. It is under the control of Ministry of Education, Government of India
    3. Dr.Santhi Swarup Bhatnagar was the first director of CSIR
    4. It is established two science museums
       I) The Birla Industrial & Technological Museum at Calcutta
       II) The Visveswarayya Industrial & Technological museum at Bangalore
    5. It provides financial help to its research institutes
    6. It provides grant in aid to research projects of universities & Industries
    7. It encourages young scientists by giving fellowship
    8. It coordinates research work carried out at different research centers
6. **ICAR**: Indian Council of Agricultural Research
    1. It is located at Delhi
    2. It is under direct control of Ministry of agriculture, Government of India
    3. It promotes agricultural research in our country
    4. It supervises the activities of agricultural research institutes and agricultural universities
7. **ICMR**: Indian Council of Medical Research
    1. It is located at Delhi
    2. Research centers are at Hyderabad, Chandigarh, Bombay, Madras
    3. It is under the control of Ministry of Health, Government of India
    4. It provides financial help to medical research in our country
    5. It gives advice to the government on health problems and family planning programmes and in evolving methods to control diseases.
8. **ICRISAT**: International Crop Research Institute for Semi Arid Tropics.
    1. It is located at Hyderabad
    2. It is concerned with the improvement of dry crop like Jawar, Bajra, Red gram, Bengal gram, Groundnut
    3. It carries research working evolving drought resistant, disease resistant and high yielding varieties of the above said dry crops.
9. **NIO**: National Institute of Oceanography
    1. It is located at New Delhi
    2. Research centres are at Bombay, Cochin, Waltair
    3. The main function is to promote research work in chemical Oceanography and geological oceanography
    4. It deals with the investigation of raw materials of marine origin
    5. It is concerned with the study of plants and animals living in the sea

6. It is controlled by CSIR

10.**NBRI**: National Botanical Research Institute

1. It is located at Lucknow
2. It undertakes research work on economically useful plants
3. The main function of the institute is the collection, introduction and propagation of vegetables, ornamental plants and other economically important plants

11.**NSC**: National Seed Corporation

1. It is located at Delhi
2. It plays an important role in the collection and preservation of seeds
3. It also distributes the seeds to the farmers at National level

12.**NIN**: National Institute of Nutrition

1. It is located at Hyderabad and Works under the perview of ICMR
2. It carries out research work on nutritional problems
3. It formulated low cost balanced diet

BRANCHES OF BIOLOGY

- Biology or Natural Science: It deals with the study of living organisms. (Greek Bios = life, Logos = discourse or Science)
- Founder of Biology: Aristotle
- Botany deals with the study of plants (Greek Botane = herb)
- Theophrastus is the Father of Botany
- Carolus Linnaeus is the father of modern Botany; father of Taxonomy
- Algalogy or Phycology: It deals with the study of algae
- Mycology: It deals with the study of fungi
- Founder of Mycology is Micheli
- Founder of modern Mycology De Bary
- Lichenology: It deals with the study of lichens
- Microbiology: It deals with the study of microorganisms like bacteria, yeasts, viruses and protozoans
- Bacteriology: It deals with the study of bacteria
- Bacteria were first discovered by Anton Von Leeuwenhock
- Virology: It deals with the study of Viruses.
- Viruses were first discovered by Ivanowsky
- The term virus was first used by Beijerinck
- Viruses were first crystalised by W.M.Stanely
- Phytophathology: It deals with the study of plant diseases caused by bacteria, viruses and fungi and their control methods.
- Bryology: It deals with the study of bryophytes. (Bryon = moss, Phyton = plant)
- Pteridology: It deals with the study of pteridophytes. The word pteridophyta originates from a greek word. (Pteron = fern) Non – flowering vascular plants.
- External morphology: It deals with external form and structure of plant organs i.e. roots, stem, leaf, flower etc
- Cytology: It deals with the study of cells
- Histology: It deals with the study of tissues and tissue systems
- Anatomy (Organography): It deals with the study of internal structure of plant organs like root, stem and leaf
- Palynology: It deals with the study of pollen grains and spores

- Embryology: It deals with the study of development of male and female gametes, fertilization and the development of embryo
- Taxonomy: It deals with the identification, nomenclature and classification of plants
- Physiology: It deals with the functional aspects of plants
- Ecology: It deals with the study of relationship between living organisms and environment
- Genetics: It deals with the study of heredity and variations
- Evolution: It is a slow process of continuous change by which higher organisms have evolved from simple unicellular organisms
- Paleontology: It deals with the study of fossils
- Palaeobotany: It deals with the study of fossils plants
- Phytogeology: It deals with the study of evolution of plants in geological periods of earth.
- Phytogeography: It deals with the study of distribution of plants
- Economic Botany: It deals with the study of plants and their products which are economically useful to man
- Agriculture: It deals with the study of crop cultivation of plants
- Agronomy: It deals with the study of field crop production
- Horticulture: It deals with the study of fruit yielding plants
- Floriculture: It deals with the study of cultivation of flower yielding plants
- Anthology: It deals with the study of flowers
- Olericulture: It deals with the study of cultivation of vegetable yielding plants
- Forestry: It deals with the protection and development of forests
- Siliviculture: It deals with the study of timber yielding plants
- Pharmacognosy: It deals with the study of medicinal plants
- Limnology: It deals with the study of fresh water plants and animals
- Pedology or Edaphology: It deals with the study of soils
- Dendrology: It deals with the study of shrubs and trees. (Woody plants)
- Agrostology: It deals with the study of grasses
- Dendrochronology: It is the study of techniques by which the age of the plant is estimated by counting annual rings
- Arboriculture: It deals with the study of cultivation of trees
- Exobiology: It is the study of life on other plants & outer space
- Plant Breeding: It is the experimental branch of botany which is concerned with the development of improved varieties of cultivated plants
- Phytology: It deals with the study of plants
- Molecular biology: It is the study of organisms at molecular level
- Biochemistry: It deals with the study of chemicals related to living organisms and their properties in living organisms
- Biophysics: It is the branch of science which deals with the physical and their properties in living organisms
- Biotechnology or Genetic engineering: It deals with the study of the methods of artificial synthesis of genes and their subsequent transplantation into the cells of an organism or methods of correcting the defective genes of organism by molecular biological techniques.

FATHER OF VARIOUS FACULTIES

- Father of Biology - Aristotle
- Father of Botany - Theophrastus
- Father of Modern Botany - Linnaeus
- Father of Phycology - G.Klebs
- Father of Mycology - Antonio Micheli
- Father of Modern mycology - Anton de Bary
- Father of Microbiology - Leeuwenhock
- Father of Bacteriology - Leeuwenhock
- Father of Virology - Ahmadjian
- Father of Immunology - Edward Jenner
- Father of Enzymology - Edward Buchner
- Father of Cytology - Robert Hooke
- Father of Genetics - Gregor Johan Mendel
- Father of Modern Genetics - T.H. Morgan
- Father of Evolution - Charles Darwin
- Father of Plant breeding - Thomas Fairchild
- Father of Plant Taxonomy - Carolus Linnaeus
- Father of Physiology - Stephen Hales
- Father of Embryology - C.F. Wolff
- Father of Tissue culture - Haberlandt
- Father of Green revolution - Norman E. Borlaug
- Father of Epidemology - John Snow
- Father of Horticulture - John Lindley

FATHERS OF FACULTIES IN INDIA

- Father of Indian Botany - Willium Roxburg
- Father of Indian Phycology - M.O.P. lyengar
- Father of Indian Mycology & Indian Plant pathology - E.J. Butler
- Father of Indian Bryology - Shivram Kashyap
- Father of Indian Taxonomy - H. Santapau
- Father of Indian Embryology - P. Maheshwari
- Father of Indian Plant physiology - J.C. Bose
- Father of Indian Paleontology - Birbal Sahni
- Father of Green Revolution of India - M.S. Swaminathan
- Father of Indian tissue culture - P. Maheshwari

Professor P. Maheshwari:

- Eminent Plant embryologist in India
- He worked extensively on Morphology, Anatomy and embryology of angiosperm.
- First botanist to induce fertilisation in angiosperms in the test tube
- Medals awarded to Maheshwari are – the prestigious Birbal Sahni medal and Sundarla Hora memorial medal
- He is the author of two books namely “An introduction to embryology of angiosperms” and “Recent advances in Embryology of Angiosperms

Dr.M.S Swaminathan:

- Father of Green revolution in India
- Father of Green revolution – Norman E Bor laug
- He introduced Mexican wheat variety to India
- He developed commercial crops like potato and jute
- The awards received by Dr.M.S Swaminathan Magasaysay, S.S Bhatnagas, awarded prize, Mendal memorial award etc
- The institute founded by Swaminathan at Chennai is M.S Swaminathan Research Institute

Indian Scientiest	**Contribution**
Prof M.O.P Iyengas	- Famous algalogist / phycologist -Studied New algae belonging to chlorophyceae -Discovered a terrestrial number of chaetophorales called Fritschiella
Prof Birbal Sahni	-Father of Indian Paleobotany -He worked extensively on flora of Indian Gondwana land -He studied the fossil flora of Rajamahal hills -He reconstructed the fossil gymnosperm group "pentoxylae" -Identified the fossil genera i.e., Homoxylon Rajmahalense. Rajmahalia paradora, and williamsonia sewardiana at Rajamahal hills. -Established Institute called Birbal Sahni Institute of Palaco botany at Lucknow
Prof Karam Chand Mehta	-Famous plant pathologist who worked wheat rust disease in India

TABLE

Term	**Year**	**Coined by**
Cell	1665	Robert Hooke
Cell membrane	1855	Nageli
Sarcode	1835	M.J Dujardin
Protoplast	1880	Hanstein
Protoplasm	1840	Purkinice
Endomembrane system	1956	de Robertis
Cytoplasm	1862	Kollickes
Ergastoplasm	1887	Garnies
Microsomes	1941	Claude
Endoplasmic reticular	1945	Portar et al
Ribosomes	1955	Palade
Mitochondrion	1897	Bends
Cristae	1955	Palade
Oxysome	1964	Lehninges
Plastid	1865	Haeckel
Chloroplast	1883	Schimpes

Term	**Year**	**Coined by**
Quantosomes	1964	Park & Pon
Cysosome	1955	Christian de Dave
Peroxisome	1963	Beautay Berthes
Nucleus	1831	Robert Brown
Chromosome	1888	Waldeyes
Heterochromatin	1928	Heitz
Euchromatin	1928	Heitz
Nucleosome	1973	Wood cock
Autosome	1904	Montgomery
Sexchromosome	1906	Wilson
Lamp brush chromosome	1892	Ruckert
Gene	1909	W.L.Johanson
Mutatoon	1901	Hugo de Vries
Genetics	1905	Bateson
mRNA	1961	Jacon & Mondal
tRNA	1957	Hoagland, Zamechidz
Tonoplast	1885	deVries
Amitosis	1882	W.Flemming
Mitosis	1883	W.Flemming
Meiosis	1905	Farmer & Moore
Synapsis	1905	Moore
Chaiarma	1909	Jansseny
Crossing oves	1912	Morgan etal
Phragmoplast	1888	Errese

Exercise –1

1) "Father of Biology" is
   1) Huxley 2) Aristotle 3) Lamark 4) Theophrastus
2) The scope of botany comprises
   1) Classification of plants 2) Description of all plants
   3) Study of uses of plants 4) Study of all about plants
3) The word "Botane" originated from the word "Bouskein" which is a
   1) Latin word 2) Greek word 3) Roman word 4) Persian word
4) The microscope which helped a lot in understanding the ultra structure of cells is
   1) Compound microscope 2) Electron microscope
   3) Phase contrast microscope 4) UV microscope
5) The device used to separate the cell organelles and cell components is
   1) Microtomy 2) Microscopy
   3) Ultra centrifugation4) Autoclaving
6) The technique used to separate the different chemical constituents of living cells is
   1) Microchemical tests 2) Staining technique
   3) Chromatography 4) Microtomy
7) The branch of Biology which deals with repairing genetic material, transfer of genes from one organism to another organism is
   1) Biophysics 2) Biochemistry3) Biometry 4) Biotechnology
8) Hieroglyphics are the representation of information in the form of
   1) Sculpture 2) Pictures 3) Scripts 4) Dance
9) Hieroglyphics had given the information regarding the known plants by

1) Greeks 2) Chinese 3) Egyptians 4) Asians

10) The veda which contains wealth of information regarding several medicinal plants and their uses
1) Samaveda 2) Atharvanaveda 3) Rigveda 4) Yajurveda

11) The oldest book on agriculture
1) Krishiparasaram 2) Vrikshayurvedam
3) Historia plantarum 4) Micrographia

12) The book written by parasara with the description of 14 forests is
1) Krishiparasaram 2) Krishisangraham
3) Vrikshayurveda 4) Historiaplantarum

13) Father of botany
1) Linnaeus 2) Bauhin 3) Parasara 4) Theophrastus

14) Book written by 'Father of Botany'
1) Krishiparasara 2) Historia plantarum
3) Micrographia 4) Species plantarum

15) Chinese learned several details of cultivation methods of plants during
1) 4000 BC 2) 2400 BC 3) 1300 BC 4) 340 BC

16) 'Herbals' are the books written by
1) Pliny & Elder 2) Brunfel's de-L'Obel & Fuchs
3) Grew & Malphighi 4) Linnaeus & Bauhin

17) The scientist who belonged to the period of herbalists and introduced the binomial nomenclature for the first time is
1) Linnaeus 2) Brunfels 3) Fuchs 4) Casper Bauhin

18) The taxonomist who successfully practised bionomial system was
1) Linnaeus 2) Theopharastus 3) Thaktajan 4) Bentham & Hooker

19) The instrument that was constructed first time by Zacharias Janssen is
1) Single handlens 2) Dissection microscope
3) Compound microscope 4) Electron microscope

20) The information of cells was published in this book by Robert Hooke
1) Microscope 2) Micrographia
3) Genera plantarum 4) Historia plantrum

21) The credit of discovery of living cells goes to
1) Robert Hooke 2) Anton van Leuwenhoek
3) Robert Brown 4) Dujardin

22) The scientists who laid foundation to anatomy during 17^{th} century are
1) Pliny & elder 2) Bauhin & Linnaeus
3) R.Hooke & R.Brown 4) Grew & Malpighi

23) Which of the following scientist is not related to taxonomy of plants?
1) Haeckel 2) de Candolle 3) Endlicher 4) Bentham

24) The phenomenon demonstrated by Stephen Hales in plants is
1) Guttation 2) Transpiration 3) Root pressure 4) Turgor pressure

25) Name of the scientist who showed that water is conducted through xylem
1) Vol Helmont 2) Stephen Hales
3) Ingen Housz 4) John Woodward

26) Father of Ecology is
1) Haeckel 2) Huxley 3) JD Hooker 4) Robert Hooke

27) Buchner discovered zymase in the cells of
1) Bacteria 2) Yeast 3) Chlorella 4) Mucor

28) The role of chromosomes in heredity was explained by
1) Sutton & Boveri 2) Skoog & Miller

3) Hofmeister 4) Waldeyer

29) The term 'gene' was introduced by
1) Bateson 2) Watson 3) Johansson 4) Robertson

30) The contribution of Frankel-Conrot to biology is the discovery of
1) Genetic nature of DNA 2) Genetic nature of RNA
3) DNA as the universal genetic material 4) Autocatalysis of DNA

31) The incorrect statement of the following is
1) 'Invitro' synthesis of RNA – Ochoa
2) Artificial gene synthesis – Khorana
3) 'Invitro' synthesis of DNA – Korenberg
4) Genetic code – Sutton and Bovery

32) Electron microscope was invented by
1) Johnson 2) Zeemik 3) W.His 4) Knoll & Ruska

33) The protein – nature of many enzymes was determined by
1) Buchner 2) Sumner 3) Hanning 4) Northrop

34) Identify the scientist who is not concerned with the development of Tissue & organ culture
1) Vishnumittre 2) Skoog 3) Maheswari 4) Hanning

35) Scientist who has no role is understanding light reaction is
1) Melvin Calvin 2) Arnon 3) Robert Hill 4) Emerson

36) The systems of classification proposed by Hallier, Bessey, Hutchinson are known as
1) Artificial systems 2) Natural systems
3) Phylogenetic system 4) Sexual system

37) Find out the wrong combination
1) F.W.Went – Auxins 2) Skoog & Miller – Gibberellins
3) Addicot – ABA 4) Garner & Allard -photoperiodism

38) Among the following the non radioactive isotope is
1) C^{14}2) N^{15} 3) S^{35} 4) O^{18}

39) The branch of Botany that deals with the statistical evaluation of genetic principles
1) Genetic engineering 2) Biometry
3) Biosystematics 4) Cytogenetics

40) Oldest branch of Botany
1) Morphology 2) Cell Biology
3) Microbiology 4) Biotechnology

41) Microanatomy is the study of
1) Microbes 2) Tissues 3) Cells 4) Cell organella

42) Comprehensive study of the cells
1) Cytology 2) Cell Biology 3) Cytogenetics 4) Histology

43) Study related to microspores
1) Microbiology 2) Microanatomy
3) Palynology 4) Mycology

44) The institute of paleobotany in India is located at
1) Lucknow 2) Luthiana 3) Leh 4) Ladak

45) The branch which deals with the study of units of "vehicles of heriditary" is
1) Cytology 2) Cell biology 3) Genetics 4) Cyto chemistry

46) In which branch of Botany we study the symbiotic association of two different groups of plants belonging to the same division?
1) Mycology 2) Microbiology
3) Lichenology 4) Limnology

47) Among the following one is not the biological significance of Lichens

1) Pioneers in plant succession 2) Indicators of air pollution
3) Biological witherers 4) Prevent acid rains

48) Association observed in bioindicators of air pollution is
1) Parasitic 2) Symbiotic 3) Independent 4) None of the above

49) Study of non vascular embryophytes
1) Phycology 2) Mycology 3) Bryology 4) Pteridology

50) Botanical snakes are
1) Mosses 2) Liver worts 3) Ferns 4) All the above

51) The branch of botany which deals with the study of first vascular land plants is
1) Bryology 2) Pteridology 3) Lichenology 4) Mycology

52) Study the acellular, sub microscopic obligate parasites is
1) Bacteriology 2) Ptotozoology
3) Virology 4) Microbiology

53) Aspect unrelated to sir JD Hooker is
1) Phytogeography 2) Botanical survey of India
3) Species plantarum 4) Flora of British India

54) Pharmocognosy is the study of
1) Effect of drugs on living organisms 2) Extraction of drugs
3) Uses of drugs 4) Preventing the usage of drugs

55) This aspect doesnot come under Biotechnology
1) Tissue & Organ culture
2) Genetic engineering
3) Production of commercial products by using transgenic plants and microorganisms
4) Study of chromosomes and DNA

56) The institute which was started to study the Flora of British India is
1) IARI 2) NBRI 3) ICRISAT 4) BSI

57) Collection and preservation of rareplants in India is the function of
1) FRI 2) BSI 3) ICAR 4) IARI

58) The famous person who had established the institute to study the floristic distribution in our country is
1) Lord curzeon 2) Henry fipps 3) Dr.Brandis 4) JD Hooker

59) The institute which was established under the guidence of lord Curzon is
1) IARI 2) ICAR 3) FRI 4) BSI

60) Financial assistance for IARI was provided by
1) JD Hooker 2) Henry Fipps 3) Dr Brandis 4) World bank

61) The research institute that is functioning as deemed university of Agricultural sciences is
1) ICRISAT 2) NBRI 3) FRI 4) IARI

62) The institute which helped to achieve self sufficiency in food grain production in our country is
1) IARI 2) ICAR 3) ICRISAT 4) NBRI

63) Unrelated aspect regarding the achievements of IARI is the establishment of
1) Radiotracer laboratory 2) Mycological herbarium
3) Water technology center 4) Modern botanical research laboratory

64) Agricultural research institutions that were started first as imperial institutions in India are
1) IARI & BSI 2) CIMAP & FRI
3) IARI & FRI 4) ICAR & NBRI

65) This research institute was started as a constituent organisation of CSIR and later elevated to an independent institute
1) NBRI 2) ICAR 3) BSI 4) IARI
66) The institute maintaining a large germplasm bank of different plant resources of our country is
1) CIMAP 2) ICRISAT 3) NBRI 4) ICAR
67) The unrelated aspect among the achievements of NBRI is
1) Bonsai technique
2) Low cost production of gums & mucilage
3) Crysanthemum varieties with prolonged blooming period
4) Developed varieties like Pusa moti & pusa red plum
68) ICRISAT maintains germplasm bank of
1) Cereals & Millets 2) Cereals & Pulses
3) Pulses & oil seeds 4) Oil seeds & fruits
69) The institutes which are considered as constituent organisations of CSIR are
1) IARI & ICAR 2) NBRI & CIMAP
3) CIMAP & ICAR 4) BSI & FRI
70) The institutes whose head quarters are located at Lucknow are
1) NBRI & CIMAP 2) NBRI & BSI
3) BSI & FRI 4) NBRI & IARI
71) The fodder grass developed by Indian agricultural research institute is
1) Pusa Rubi 2) Pusa gaint napier grass
3) Sugandha 4) Pupalia grass
72) The National institutes whose head quarters are located in New Delhi are
1) BSI & FRI 2) NBRI & CIMAP
3) IARI 4) IARI & CIMAP
73) The aspect unrelated to FRI
1) Checking deforestation
2) Research on paper pulp
3) to train up forest officers and rangers
4) production of geranium oil & citronella oil
74) The plant discovered by MOP Iyngar is
1) An aquatic alga 2) A terrestrial alga
3) A heterotrophic alga 4) A prokaryotic alga
75) The member of chatgophorales discovered by
1) Fritschiella 2) Chlorella 3) Centella 4) Ravenella
76) The plant that helped algologists to understand the origin of the land habit in plants is
1) Clamydomonas 2) Marchantia 3) Fritchiella 4) Marchantia
77) MOP Iyengar is considered to be the pioneer in research work on
1) Aquatic flora 2) Marine flora
3) Aquatic fauna 4) Phytoplanktonic flora
78) Father of green revolution
1) MS Swaminathan 2) Norman E Borlaug
3) KC Mehta 4) P Maheshwari
79) Mexican dwarf varieties of wheat were created by
1) KC Mehta 2) MS Swaminathan
3) Normal E Borlaug 4) Prof B Sahni

Keys

1)2	2)4	3)2	4)2	5)3	6)3	7)4	8)2
9)3	10)2	11)1	12)3	13)4	14)2	15)2	16)2
17)4	18)1	19)3	20)2	21)2	22)4	23)1	24)3
25)2	26)1	27)2	28)1	29)3	30)2	31)4	32)4
33)2	34)1	35)1	36)3	37)2	38)4	39)2	40)1
41)2	42)2	43)3	44)1	45)3	46)3	47)4	48)2
49)3	50)3	51)2	52)3	53)3	54)2	55)4	56)4
57)2	58)4	59)1	60)2	61)4	62)1	63)4	64)3
65)1	66)3	67)4	68)2	69)2	70)1	71)2	72)3
73)4	74)2	75)1	76)3	77)4	78)2	79)3	

Exercise- 2

1) K.C.Mehta studied annual reoccurrence of rust disease in
i) Sugarcane ii) Wheat iii) Paddy iv) Barley
1) II alone is correct 2) IV alone along is correct
3) II & IV are correct 4) III & IV are correct

2) M.S.Swaminathan worked as
I) Director of IARI II) Director general of IRRI
III) Director of ICRISAT IV) Director of ICAR
1) Both I & II are correct 2) I alone is correct
3) II alone is correct 4) III & IV are correct

3) Birbal Sahni was associated with
I) Extensive research on Himalayan flora II) Flora of Indian godwana land
III) Reconstruction of Pentoxylae IV) Discovary of Fritschiella
1) I alone is correct 2) II alone is correct
3) III alone is correct 4) II & III are correct

4) Study the following lists:

List –I	List –II
A) Maheshwari B) Birbal Sahni C) K.C.Mehta D) Iyengar	I) Palaeobotany II) Phycology III) Embryology IV) Plant breeding V) Plant pathology

1) A-III, B-I, C-V, D-II 2) A-III, B-IV, C-V, D-I
3) A-IV, B-I, C-V, D-II 4) A-IV, B-II, C-III, D-I

5) Study the following lists:

List –I	List –II
A) Father of Indian green revolution B) Indian palaeobotanist C) Indian Embryologist D) Indian Algalogist	I) M.S.Swaminathan II) M.O.P.Iyengar III) P.Maheswari IV) K.C.Mehta V) Birbal Sahni

1) A-IV, B-V, C-I, D-III 2) A-I, B-V, C-II, D-III
3) A-I, B-V, C-III, D-II 4) A-III, B-II, C-IV, D-V

6) Study the following lists:

List –I	List –II
A) Fritschiella B) Rust in wheat C) Pentoxylae D) In vitro fertilization	I) K.C.Mehta II) M.S.Swaminathan III) Birbal Sahni IV) P.Maheswari V) M.O.P.Iyenger

1) A-I, B-II, C-III, D-IV 2) A-II, B-I, C-IV, D-III
3) A-V, B-IV, C-I, D-III 4) A-V, B-I, C-III, D-IV

7) Study the following table

Scientist	Branch of Botany	Research work
I) M.O.P.Iyenger	Embryology	Fertilization in Fritischiella
II) Birbal Sahni	Palacobotany	Reconstructions of Pentoxylae
III) P.Maheswari	Embryologist	Fertilization in Angiosperms in test-tubes
IV) K.C.Mehta	Taxonomist	Monocots

Which tow items show correct combination?
1) II & III 2) I & II 3) III & IV 4) I & IV

8) Preparation of comprehensive herbarian of Indian flora and its preservation is one of the functions of
I) BSI II) IARI III) NBRI
1) I alone is correct 2) I & II are correct
3) I & III are correct 4) I, II & III are correct

9) Study the following lists:

List –I	List –II
A) Sutton and Boveri B) Fraenkelin and Conrot C) Beadle and Tatum D) Jacob and Monod	I) One gene-one enzyme hypothesis II) Genetic nature of RNA III) Operon concept IV) Artificial synthesis of gene V) Chromosome theory

1) A-I, B-II, C-III, D-IV 2) A-V, B-I, C-IV, D-I
3) A-V, B-II, C-I, D-II4) A-II, B-III, C-I, D-IV

10) Study the following lists:

List –I	List –II
A) Parasara B) Robert Hooke C) Bauhin D) Theophrastus	I) Historia plantarum II) Micrographia III) Vrikshayurveda IV) Krishiparasaram V) Binomial system

1) A-III, B-II, C-V, D-I 2) A-III, B-V, C-II, D-I
3) A-I, B-II, C-III, D-IV 4) A-II, B-III, C-I, D-IV

11) Study the following lists:

List –I	List – II
A) BSI B) IARI C) FRI D) ICRISAT	I) FAO, WB II) Brandis III) CSIR IV) JD Hooker V) Lord Curzon

1) A-IV, B-V, C-II, D-I 2) A-IV, B-V, C-I, D-II
3) A-IV, B-III, C-II, D-I 4) A-V, B-IV, C-III, D-II

12) Study the following lists:

List –I	List –II
A) P.Maheshwari B) B.Sahni C) Iyengar D) K.C.Mehta	I) Highly evolved terrestrial alga is Fristschiella II) Source of inoculum responsible for annual reocurrence of wheat rust III) Fertilization in test tube IV) Introduction of mexican dwarf varieties of wheat V) Reconstruction of fossil gymnosperm group pentoxylae

1) A-III, B-V, C-I, D-II 2) A-III, B-I, C-II, D-IV
3) A-I, B-II, C-III, D-IV 4) A-II, B-IV, C-I, D-IV

13) Assertion: K.C.Mehta was a plant pathologist
Reason: He studied the reason for the annual reoccurrance of rust diseases in wheat & Barely
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

14) Assertion: Birbal Sahni investigated the fossil flora of Raj Mahal hills
Reason: He reported several new genera of fossil plants
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

15) Assertion: M.S.Swaminathan is popularly known as the father of green revolution in India
Reason: He was the director of IARI
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

16) Assertion: Swaminathan took up the task of promoting agricultural research in India
Reason: Swaminathan introduced Mexican varieties of wheat into India
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

17) Assertion: Development in other branches especially in chemistry has helped biology to progress
Reason: Microchemical tests have helped us to understand the functions and chemical reactions that take place in different organelles
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

18) Assertion: Gregor John Linnaeus became popular as the “Father of Genetics”
Reason: He conducted hybridisation experiments on pea plants
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false

4) A is false but R is true

19) Assertion: Bryophytes are poorly adapted to life on land
Reason: Bryophytes are amphibious and prefer cool moist & shady places
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

Keys

1) 3	2) 4	3) 4	4) 1	5) 3	6) 4	7) 1
8) 1	9) 3	10) 1	11) 1	12) 1	13) 1	14) 2
15) 2	16) 1	17) 1	18) 2	19) 1		

PLANT KINGDOM

- Large number of living organisms are present on the earth. Living organisms includes both plants & animals. Man depends on various kinds of plants for existence.
- Plant exhibits variations in size, form, structure & reproduction. They have been evolving with increasing complexity & diversity. Because of wide diversity among plants, plants are classified into different plant groups such as Thallophytes, Bryophytes, Pteredophytes, Angiosperms & Gymnosperms

PLANT BODY: Thallophytes are the plants with least structural differenciation

- Plant body is known as 'Thallus' which is not differencitated into true root system & shoot system.

Thallophytes includes algae & fungi

- Plants may be unicellular or multicellular
- Multicellular forms includes colonial, filamentous, heterotrichous, pseudoparenchymatous thalli
- Most of the algae are simple but some marine forms exhibits structural differenciation of thalli
- Lichens are the plants formed by association of algae & fungi
- **Bryophytes**: are small groups of plants which are called as "amphibians of plant kingdom".
- Plants lack true root, stem & leaves
- Thallophytes & Bryophytes are non-vascular cryptogams

Pteridophytes: non flowering terrestrial plants

- Plant body is differenciated into true root, stem & leaves
- Pteridophytes are the vascular cryptogams as they possess xylem & phloem

Gymnosperms & Angiosperms: are the seed plants which shows highest development & differenciated

- Plant body is differenciated into true root, stem & leaves
- Vascular system is highly developed

REPRODUCTION: In plants reproductive units consists of whole or a part of the plant. In Unicellular forms, entire adult cell is the reproductive unit. In multicellular plants, the reproductive unit consists of a part of vegetative body or a single called spore or gametes

- Plants reproduces by three different methods
  Vegetative Reproduction
  Asexual Reproduction
  Sexual Reproduction

Vegetative Reproduction:

- It does not involve the formation of special reproductive cells
- In this method a portion of the thallus separates from the plant body & develops into new plant
- Various methods of vegetative reproduction are cell division, budding, tubers, bulbils, suckers & fragmentation
- Vegetative reproduction is useful to maintain the same genotype of the plant through generations without variation
- It is usually seen in primitive plants like Cryptogams

Asexual Reproduction:

- It is very common in Thallophytes
- It is carried out by special unicellular reproductive cells called spores, such as zoospores, aplanospores, chlamydospores, conidia, akinetes, exospores, endospores
- Spores may be motile or non-motile. During favourable conditions they directly develop into new plant body.
- Asexual spores play an important role in geographical distribution of plants

Sexual Reproduction:

- It is the most advanced type of reproduction
- Gametes are the special sexual cells formed during sexual reproduction
- Gametes are haploid. Male & female gametes fuse to form diploid zygote
- Fusion of gametes is known as syngamy or fertilization
- Depending upon the structure, nature & physiology of fusing gametes, sexual reproduction is of three type ----
  Isogamy
  Anisogamy
  Oogamy

Isogamy: "Fusion of two structurally & functionally similar gametes is known as isogamy".

- Isogametes are formed by the transformation of the protoplast of the body cell
- In some cases the fusing gametes are morphologically similar but physiologically different. Such fusion is known as 'Physiological anisogamy' or 'Morphological isogamy'.

Anisogamy: "Fusion of two morphologically & physiologically different gametes is known as anisogamy".

- Fusing gametes are different in size as well as in function

- The smaller gametes are microgametes & larger gametes are macrogametes

Oogamy: "Fusion of large, always non-motile female gamete (egg or Ovum) & a small motile or non-motile male gamete (spermatozoid) is called as Oogamy".

- It is the most advanced type of sexual reproduction
- It is of two types ----

341) Zooidogamy
342) Siphonogamy
343) Zooidogamy: Male gamete is motile & pollen tube is not formed
344) Siphonogamy: Male gamete is non-motile & pollen tube is formed

- In Thallophytes, the sex organs are unicellular & are not surrounded by sterile jacket layer. Highly specialized multicellular sex organs are present in Bryophytes, Pteridophytes & Gymnosperms
- Male sex organ – Antheredium
  Female sex organ – Archegonium
- The plants which produce archegonia are known as 'Archigoniates'. During fertilization motile male gametes swim to reach the egg (zooidogamy) or carried by pollen tube up to vicinity of egg (siphonogamy)
- In Thallophytes, zygote immediately undergo meiosis & forms spores. But in advanced plants embryo is formed as a result of repeated mitotic divisions. The plants which produce embryo in their life history are known as 'Embryophytes'.
- Sexual reproduction is the basic mechanism for natural evolution. It brings about new combination of genes & results in natural variations. These variations leads to evolution due to natural selection

LIFE CYCLES: The life cycle of every plant passes through a number of stages like germination, growth, differenciation, reproduction, death etc.

- Gametophyte – the stage showing sexual reproduction
- Sporophyte – the stage showing asexual reproduction
- The sequence of the orderly changes of the life history are represented in a circular sequence known as 'Life cycle' or 'Life history'.
  Hence life cycle is a process which begins with one individual & continues till a new generation of similar individuals is produced again
- Based on morphological & cytological consideration life cycles are of different types ----

  Haplontic life cycle
  Diplontic life cycle
  Diplohaplontic life cycle (Digenetic life cycle)
  Haplobiontic life cycle
  Diplobiontic life cycle (Trigenetic life cycle)

Haplontic Life Cycle: It is pecialized s by the alternation of predominantly haploid phase (i.e. gametophyte) with a very short diploid phase (i.e. sporophyte). Diploid phase is restricted to zygote only.

Ex: Spirogyra, Rhizopus etc

Diplontic Life Cycle: In this type of life cycle the vegetative phase is diploid & haploid phase is restricted to gametes only.

Ex: Fucus, Sargassum, Saprolegnia etc

Diplohaplontic Life Cycle: (Digenetic Life Cycle)

- In this type of life cycle both gametophytic & sporophytic generations are predominant & regular alternation takes place between the two generations. Which is known as "Alternation of Generation". It is of two types ----
  - Isomorphic alternation of generation
  - Heteromorphic alternation of generation
- In Heteromorophic alternation of generation, the two alternating phases are morphologically dissimilar
  Ex: Lamenaria, Funaria, Pteris, Cycas & Angiosperms etc
- In Isomorphic alternation of generation the two alternating phases are morphologically similar
  Ex: Dictyota, Ectocarpus

Haplobiontic Life Cycle: In this type of a single diploid phase alternates with two dominant haploid phases. Ex: Batrachospermum

Diplobiontic Life Cycle: (Trigentic Life Cycle)

In this type of life cycle the gametophytic & sporophytic generation are elaborately developed. A single diploid phase alternates with two diploid phases

Ex: Polysiphonia

HOMOSPORY & HETEROSPORY:

- The phenomenon of "production of only one type of spores by the sporophyte is known as homospory". All bryophytes & many pteridophytes are homosporous
  Ex: Marchantia } Bryophytes
  Funaria
  Lycopodium } Pteridophytes
  Equisetum
- "Production of two different types of spores in the same species is known as heterospory". Microspores & megaspores are of two different types of spores
  Microspore $\rightarrow$ Male gametophyte
  Megaspore $\rightarrow$ Female gametophyte
  Ex: Selaginella, Azolla, Marsilea etc
- The phenomenon of heterospory is considered as prerequesite to "Seed habit" in spermatophyta Angiosperms dominate the present day vegetation & their success is due to their seed habit.

CLASSIFICATION OF PLANT KINGDOM

1) All the plants which inhibit the earth are included in plant kingdom i.e., "PLANTAE"

2) Plant kingdom is divided into two major groups or sub-kingdoms based on the presence & absence of flower.
    345) Cryptogams – non flowering plants
    346) Phanerogams – flowering plant

CRYPTOGAMS:

3) The term Cryptogams was first introduced by Linnaeus (1737)
4) The plant body is not well organized
5) They do not bear flowers, fruits & seeds
6) These are the plants with hidden reproductive organs
7) Plants normally reproduce asexually by spores& sexually by gametes. They do not produce seeds,hence cryptogams are also known as 'Sporophyta'
8) Eichler (1886) divided cryptogams into three divisions
   i)Thallophyta ii) Bryophyta iii) Pteridophyta

Div: Thallophyta:[Thallos = young shoot, phyton = plant]

1) It is the largest division & was introduced by Endlicher (1836)
2) This division includes plants with simple structure called 'Thallus'
3) They are mostly found in water moist places & on decaying organic matter
4) Thallus is not differenciated into root, stem & leaves
5) Thallus rages from microscopic unicellular forms to macroscopic multicellular forms. They may be chlorophyllous or achlorophyllous
6) Plant are non-vascular as xylem & Phloem is absent – Atracheophyta
7) The reproductive organs are simple & mostly unicellular. If sex organs are multicellular sterile jacket is absent
8) Embryonic stage is absent [Non – embryophaytes]
9) They reproduces asexually by spores & sexually by isogamous, anisogamous or oogamous methods
10) Thallophytes are divided into two sub-division based on nutrition
    I) Algae II) Fungi

Sub – Divison – Algae: The word 'Algae' was first coined by Linnaeus (1753)

1) The study of algae – Phycology / Algalogy Phykos = Sea weeds; logas = discourse
2) Chlorophyll bearing, autotrophic aquatic thallophytes are called as Algae.
3) Plant body is simple thallus
4) Large marine algae are sea weeds/ kelps
5) Cell wall is usually made up of cellulose
6) Reserve food material is starch
7) F.E.Fritch (1935) classified algae into 11 classes on the basis of type of pigment, manufacture of reverse food & method of reproduction. The classes are.
    1) Chlorophyceae – Green algae
    2) Xanthophyceae – Yellow algae
    3) Chrysophyceae
    4) Bacellariophyceae
    5) Cryptophyceae
    6) Dinophyceae
    7) Chloromonadinae

8) Englenineae
9) Phacophyceae - Brown algae
10) Rhodophyceae – Red algae
11) Myxophyceae – Blue green algae

Sub Division – Fungi: Fungi are alchlorophyllous, Non- Vascular. The study of fungi is known as Mycology [Mykes = mushroom, logos = discourse]

Antonio Micheli [an Italian botanist] is the founder of mycology &

De bary is known as founder of modern mycology

Fungi usually grown on moist substratum

Plant body consists of intervoven branched hyphae called mycelium

Photosynthetic pigments are absent hence they lead heterotrophic mode of life

Cell wall is made up of chaitin

Reserve food is in the form of glycogen & fat globules

Sex organs are usually unicellular in fungi & show progressive degeneration

Fungi reproduce asexually by spores & sexually by gametes

Based in nature of mycelium & mode of reproduction, Alexopoulos (1952) recognized Nine classes these are (old classification)

1) Chytridiomycetes 2) Hypochytridiomycetes
3) Oomycetes 4) Plasmodiophoromycetes
5) Zygomycetes 6) Trichomycetes
7) Ascomycetes 8) Basidiomycetes
Deuteromycetes

Fungi are sub-divided into 4 classes these are

1) Phycomycetes - Algae fungi
2) Ascomycetes – Sac fungi
3) Basidiomycetes – Club fungi

Deuteromycetes – Fungi imperfecte

Division – Bryophyta: Bryophytes are a small group of plants which are commonly called “Amphibians of plant kingdom”.

a. The word Brypophyta was coined by “Brown”
b. Study of Bryophytes – Bryology
c. The occur in damp, shady & humid localities
d. They are non-vascular cryptogams
e. Plant body is a gametophyte. In primitive forms it is thalloid Ex: Riccia. In higher forms plant body is differentiated into rhizoids, stem & leaves
   Ex: Mosses (funaria)
f. Gametophyte is the dominant phase & is highly evolved
g. From the lower surface of the thallus number of unicellular or multicellular rhizoids develop which helps in fixation & absorption
h. Bryophytes reproduces vegetatively by tubers, gammae protonema etc
i. Sexual reproduction is Oogamous

j. Sex organs are antheridia (male) & archegonia (female) which are always multicellular
k. Male gametes are motile & biflagellate & are produced in antheridia
l. Archegonium is flask shaped having Venter & long neck
m. Water is essential for fertilization & dehiscence of sex organs. Male gametes show chemotactic movement
n. Fertilized egg is retained in the venter of archegonium. It develops to form sporophyte.
o. Sporophyte is either complete or partial parasite on gametophyte
p. Sporophyte consists of foot, seta & capsule
q. Sporophyte produce haploid, non motile spores after merosis
r. Spores are of one king – homosporous
s. All bryophytes shows hetermorphics alternation of generation
t. Rothmaler (1951) divided bryophytes into 3 classes
1) Hepaticopsida - Liver worts
2) Anthocerotopsida - Horn worts
3) Bryopsida - Mosses

Div. Pteridophyta: Pteridophytes are considered as highly evolved group of cryptogams. They are also known as vascular cryptogams [Tracheophytes] as they possess xylem & phloem. They are nick named as “Botanical snakes”.

1) They are terrestrial plants which grow well on moist shady localities
2) Sporophytes is the dominant stage in the life cycle of pteridophytes & is represented by true roots, stem & leaves
3) Root system is always adventitious
4) Stem may be aerial or rhizomatous
5) Leaves may be microphyllous or macrophyllous
6) These are the first plants which have vasculature
7) Xylem consists of tracheids & phloem consists sieve cells
8) Sporophyte reproduces asexually by spores produced in sporangia
9) Sporophyte may be “homosporous”. [Ex: Lycopodium Equisetum] or heterosporous [Ex: Selaginella, Marsilea]
10) Development of sprogphyte may be
    a) Leptosporangiate – Development of sporangium from single sporangial initial. Ex: Pteris
    b) Eusporangiate – Development of sporangium from a group of sporangial initials. Ex: Selaginella
11) Gametophyte has a simple structure and is known as prothallus. It is independent & bears the reproductive organs
12) Prothalli may be monoecious or dioecious
13) Sex organs are antheridium & archegonium
14) Spermatozoids are antherozoids are uninucleate, spirally coiled, flagellate, multiflagellate structures & show chemotactic movement
15) Zygote shows “insitu” development & forms embryo – [Embryophyta]
16) Young sporophyte is dependent on gametophyte in earlier stages on the gametophyte

17) Pteridophytes shows regular heteromorphic alternation of generation
18) These are the only plants in which both gametophyte & sporophyte are independent
19) Pichi –sermolli (1958) divided into six classes
    347) Psilophylosida
    348) Psilotopsida
    349) Lycopsida
    350) Sphenopsida – Horse tails
    351) Noeggerathipsida
    352) Filicopsida / Pteropsida – Ferns

Phanerogams: [Phanero = visible]

The following plants or steel plants are called as “Phanerogams”.
They are included in a division known as “Spermatophyta”.
(Sperma = seed, Phyton – plant)

1) Plant body is differentiated into root. Stem & leaves; & possess vascular system.
2) Plants bears visible reproductive structures like flowers & cones
3) Plants bears specialized sporophylls
4) Microsporophylls (Stamens) bear microsporangia & megasporophylls (carpels) bear megasporangia or ovules
5) Plants reproduce sexually by gametes
6) Male & female gametophytes are small, not well developed & depends upon sporophyte for nutrition
7) Fertilization is sphonogamous type
8) Division Spermatophyta is divided into two sub-division
   i) Gymnospermae ii) Angiospermae

Sub.Division: Gymnospermae:

[Gymnos = naked, sperma = seed]

The term Gymnospermae is coined by Theophrastus (300B.C). These are the naked seeded plants having freely exposed ovules on megasporophylls. They occupy the intermediate position between Pteriophytes & Angiospermae

1) Most of the genera are entirely extinct & only a few are living
2) Gymnosperms are woody plants represented by sporophyte
3) Sporophytic plants are ever green & is represented by root, stem & leaves
4) The tallest living gymnosperm is sequiodendron giganeum [100mts height]
5) Roots show diarch to polyarch condition
6) Leaves may be dimorphic or monomorphic
7) Plants possess vascular tissue
8) Xylem is mainly made up of tracheids
9) Phloem lacks companion cells
10) Tracheids posses bordered pits. Secondary xylem may be manoxylic or pycnoxylic
11) Sporophylls aggregate to form strobilus / cone
12) Ovules are unitegmic & orthotropus
13) Gymnosperms are heterosporous

14) Polyemybryony is commonly seen
15) Endosperm is haploid & is prefertilized product
16) Sporne (1965) divided gymnosperms into three classes-----
    353) Cycandopsida
    354) Coniferopsida
    355) Gnetopsida

Sub – Division: Angiospermae:

[Angios = Sac / vessel; Sperma = seed]

1) Angiosperms are the highly evolved plants & forms the dominant vegetation
2) Sporophyte is the dominant phase of life cycle
3) Sporophyte is represented by root, stem & leaves
4) Vascular tissue is very well developed. Xylem is with vessels & phloem shows companion cells
5) Distinct secondary growth is seen
6) Flowers carry out sexual reproduction
7) Androecium & gynoecium are surrounded by non-essential organs (sepals, petals)
8) Pollination is indirect as ovules are inside the ovary
9) Angiosperms are characterized by double fertilization & triple fusion
10) Angiosperms are sub-divided into 2 classes
    i) Dicotyledonae ii) Monocotyledonae

Class: DICOTYLEDONAE:

1) Root system is of tap root type
2) Leaves shows reticulate venation
3) Stem shows collateral or bicollateral, open vascular bundles
4) Flowers are tetramerous or pentamerous
5) Seeds have two cotyledons Ex: Bean, Sunflower, Datura etc

Dicotyledonae is divided into three large groups
namely Polypetalae, Gamopetalae & Monochlamydae

Class: MONOTYLEDONAE:

1) Root system is of adventitious type
2) Leaves with parallel venation
3) Stem possess collateral & closed vascular bundle
4) Flowers are trimerous
5) Seeds have one cotyledon Ex: Rice, Wheat, Maize etc

The class monocotyledonae is divided into seven classes (Bentham & Hooker)

UNIT –II
STRUCTURAL ORGANISATION IN PLANTS

MORPHOLOGY OF A FLOWERING PLANT

- Plants & Animals are living organisms
- Plants can be differenciated from animals by autorophic mode of nutrition, growth throughout their life, cellulose cell wall etc.
- The Plant body consists of root system & shoot system

Root System:

- It is underground & positively geotropic
- It develops from radical of embryo
- It is non-green in colour & is not differenciated into nodes & internodes
- Leaves & buds are absent
- Lateral roots arises endogenously from Pericycle
- Root cap & root hairs are present
- In dicots, radical develops into tap root which inturn produces lateral root. Lateral roots bears root hairs which helps in absorption of water
- This system is known as tap root system which is the characteristic feature of decot plants
- In monocots, radicals is short lived & soon after its disintegration many identical roots develops from the base of stem. These roots are known as fibrous roots or adventitious roots & the system is known as fibrous root system

Shoot System:

- It is the aerial part of the plant body
- It arises from plumule of embryo
- It is positively phototropic, negatively geotropic
- Main axis of shoot system is known as stem.
- It bears branches, leaves, buds & flowers.
- It is differenciated into nodes & internodes
- Main stem & branches ends with apical or terminal bud. It helps in vertical growth of the stem
- The angle between upper part of leaf & the stem is known as axil
- Buds present in the axil of leaves are known as axillary buds. It may develop into vegetative shoot or reproductive shoot.

Leaf:

- It is the lateral appendage of the stem
- It is dorsoventrally flattend, green structure
- It consists of leaf base, petiole & lamina
- It is chiefly concerned with photosynthesis & transpiration

Flower:

- It is modified reproductive shoot
- It may develop singly or in groups (inflorescence)
- Flower consists of pedicel which ends with thalamus
- Thalamus bears floral leaves like calyx, corolla, androecium & gynoecium
- The main function of flower is to carry out sexual reproduction
- Fruits & seeds are resultant products of sexual reproduction

THE ROOT

- The underground part of plant body that develops from radical of embryo is known as 'root'.
- It is positively geotropic & negatively phototropic
- It is non –green in colour
- It is not differenciated into nodes & internodes
- Leaves & buds are absent
- It produces lateral roots endogenously
- Root apex is protected by calyptra which is composed of calyptrogen tissue. It gives protection to the meristematic region & helps in easy penetration of root into the soil.
- Primary root, secondary root & tertiary root constitute root system
- Root system is of two different types
  - i) **Tap root system**: In this type radical develops into primary root or tap root. It produces lateral roots in acropetal succession which is turn produces tertiary roots.
  - ii) **Adventitious or Fibrous roots system**: The root which arises from any part of plant body except radical is known as adventitious root system. It is the characteristic features of monocots. In this type root develops from radical which short lived, new roots develops from the base of the stem.

Regions of Root:

Root shows four distinct regions

i) Meristematic region (Region of root cap)
ii) Elongation region
iii) Root hair region
iv) Maturation region

i) **Meristematic Region**:

- It consists of meristematic cells & is responsible for growth
- It is covered by root cap or calyptra
- Calyptra is formed from calyptrogen tissue
- Calyptra gives protection to meristematic tissue & also helps in penetration
- Largest & persistant root cap is seen in Pandanus

ii) **Elongation Region**:

- It is present behind the meristematic region
- Cells elongates rapidly & responsible for elongation of roots
- This region helps in salt absorption
- Tissue differenciation starts in this region

iii) **Root hair Region**:

- It is present behind the elongation region
- Epidermal cells of this region produce tubular out growths known as root hairs& hence in this region epidermis is known as puliferous layer
- It is responsible for absorption of water

iv) **Maturation Region**:

- It is behind root hair region
- Tissue differenciation completes in this part
- Lateral roots arise endogenously from this region
- It helps in conduction of water & nutrients

Functions of Roots:

- It helps in fixation of plant in the soil
- Absorbs water & mineral salts from soil
- Conducts water & mineral salts to other parts of plant body

ROOT MODIFICATIONS

- Any change in the structure of any plant part to carry out new function according to climatic conditions is known as modification
- "When a permanent change occurs in the structure of the root to carry out new functions suitable for the environment is known as root modification".
- Based on the need, entire root or a part of the root is modified to carryout new functions
  Some important root modifications are-----

1) **Tuberous roots or Storage roots**:

- In some autotrophic plant, excessive amount of food material is stored in the roots for future use.
- Such roots becomes tuborous due to storage of food & are known as storage roots or tuberous roots.
- These roots are seen in biennials like Daucus carota, Raphanus satirus, Beta vulgaris, etc
- Biennials shows vegetative growth in first year & store the food materials. In the second year the stored food material is utilised for production of flower, fruits & seeds. Hence these plants (root crops) are harvested at the end of first year only.
- The plants which are grown for tuberous roots are known as root crops. In these plants tap roots store food & attains different shapes
  Raphanus sativus (Radish) --- Spindle shaped
  Daucus carota (Carrot) ---- --- Conical shaped
  Beta vulgaris (Beet root) ----- Nap form
- In same plants adventitious roots stores food
- Single adventitious tuberous root Ex: Ipomoeabatatus
- Fasciculated tuberous roots Ex: Dahlia, Ruellia, Asparagus
- In B.vulgaris food is stored in the form of sugars.
- In Dahlia food is stored in the form of inulin

2) **Velamen Roots (Epiphytic roots)**:

- Plants which grows on the branches of other plants for the sake of shelter are known as epiphytes
- Epiphytes are commonly seen in Tropical forest
- Epiphytic habitat helps the plants in getting proper sunlight
- Epiphytes produce two types of roots (a) Clinging roots (b) Velamen roots
- Clinging roots are small, branched, grows into the crevices of the host & helps in fixation
- Velamen roots are long, branched & hangs freely in the air
- These roots contain dead, hygroscopic tissue known as velamen tissue
- Velamen tissue helps in absorption of moisture from atmosphere
- Velamen roots are found in the members of Orchidaceae & Aroedae
  (Vanda, Oberonia)

3) **Photosynthetic Roots (or) Assimilatory Roots**:

- The roots which prepare the food materials by photosynthesis is known as assimilatory roots/ Photosynthetic roots
  Ex: Taeniophyllum, Tinospora, Trapa etc
- Taeniophyllum is a epiphyte & shows Xerophytic adaptation. Stem & leaves are absent or almost reduced
  The plant is represented by green, flattened, velames roots known as photosynthetic roots
- These roots carry out photosynthesis & also helps in absorption of moisture
- Assimilatory roots are also found in hydrophytes like Trapa & Podostemon

4) **Nodular Roots**:

- These roots are present in Leguminosae members
- These plants have nodules on their roots, hence these roots are known as nodular roots
- These roots are symbiotically associated with Rhizobium bacteria
- These Bacteria converts atmospheric nitrogen into nitrogenous compound & fix them into the soil. Which are absorbed by plant. The plant inturn provide shelter & food to Bacterium →Symbiosis
  Ex: Dolichos, Pisum Arachis, Crotolaria etc

5) **Pnematophores (or) Respiratory Roots**:

- These are commonly found in Mangroves
- Plants which are live in saline marshy soils or waterlogged soils are known as mangroves
- Marshy soil is poor in oxygen content & hence mangroves suffers oxygen deficiency
- In these plants, some of the roots becomes aerial & helps in respiration
- These aerial roots bears minute pores on them, which are known as Pnemathodes.
- Pnemathodes helps in exchange of gases
- The roots which bears Pneumathodes are known as Pnematophores
  Ex: Avicennia, Rhizophora, Jussiaea etc

6) **Parasitic Roots (or) Haustorica**:

- Plants which are depends upon other plants for them nutrition are parasites
- Parasitic plants produce modified roots into the host which are called haustoria
- Haustoria enters into the host stem or root & draw the required nutrients
- Root parasites →draws nutrients from host root
- Stem parasites →draws nutrients from host stem

Parasites

- Stem Parasite
  - Complete stem Parasites
    Ex:Cuscuta
  - Partial stem Parasites
    Ex:Viscum
    Coranthus
- Root Parasites
  - Complete root parasite
    Ex: Orobanche
    Raffleria
    Balonophora
  - Partial root parasite
    Ex: Striga

- Partial parasites absorbs only mineral water from host
- Complete parasites are non green & absorb minerals & organic food material from host

7) **Prop roots**:
- Pillar like aerial adventitious roots which give additional support to horizontal branches are known as prop roots. Ex: Ficus benghalensis (Banyan)
- In Banyan Free, branches are large & spread horizontally. These branches may bend down wards due to their own weight or may even break
- To prevent this, adventitious develops from branches, becomes pillar like & gives support to branches

8) **Stilt Roots**:
- Aerial, adventitious roots that develops from the lower nodes of stem to give additional support are known as stilt roots
  Ex: Maize, Sorghum, Pandanus, Rhizophora
- Maize & Sorghum have long & reedy stem with shallow root system.
- Pandanus grows is sandy or marshy soil
- These plants require additional support & hence stilt roots grows obliquely into the soil.

9) **Climbing Roots**:
- Aerial, adventitious roots which help the weak stemmed plants to climb over the support are known as climbing roots
  Ex: Piper betel, Hedira, Vanilla, Pothos

10) **Balancing Roots**:
- Adventitious roots which maintains the balance of free floating hydrophytes are balancing roots.
  Ex: Pistia, Elchlornia etc
- In free floating hydrophytes balancing roots acts as dead weight & prevent the toppling of plants due to wind currents

11) **Buttress Roots (or) Plank Roots**:
- Plank like roots that arises from the base of stem & grows horizontally on soil surface are known as Plank roots
- These roots grows in all directions & gives mechanical support to huge trunk
  Ex: Terminalia, Salmalia

THE STEM

- The aerial part of the plant body that develops from the plumule of embryo is known as shoot system.
- Shoot system consists of stem, leaves & flowers.
- The axis of the shoot system is called as stem.
- Stem is differenciated into nodes & internodes
- The stem bears the weight of the plant
- It conducts water & minerals to shoot system & food materials to the root system.
- It helps to display the foliage
- Woody stems are found in shrubs & trees
- Based on the growth of main stem & arrangement of branches & trees are classified into-----
- **Deliquescent**: Ex: Tamarindus, Mango, Ficus etc

- Stem is prominent
- It bears branches which spreads in different directions. Plant attains umbrella shape.
- **Excurrent**: Ex: Pinus, Polyalthia, Casurina, Eucalyptus etc
- Main stem shows indefinite growth
- Lateral branches develops in acropetal succession & hence appear cone shape
- **Caudex**: Ex: Cocos, Phoenix (Date palm), Borassus etc.
- Stem is long, stout & unbranched
- It bears a crown of leaves at the apex. Commonly found in palms
- Stems of herbs are weak & known as herbaceous stem
- **Culm**: Long, reedy stem which appears to be jointed at each node is called as culm.
  (Stem appears articulated at each node.)
  Ex: Bamboo, Maize, Sugarcane, Grasses etc.

Pseudostem:

- In some plants stem is underground.
- Aerial stem like structure is formed by overlapping of sheathing leaf base is known as Pseudostem
- The reproductive shoot that passes through, the centre of Pseudostem & becomes aerial is known as scape
  Ex: Musa, Canna, Curcuma etc

Prostrate stem: The stem which is rooted at one place & creeps in all direction is prostrate stem

Prostrate Procumbent: The stem is rooted at one place & creeps over the soil throughout the length Ex: Tribulus, Heylandia

Prostrate Decumbent: In thin case the stem creeps over the soil to certain length & then terminal part of the stem stands erect. Ex: Tridax

Climbing Stem:

- Weak herbaceous stem that climb over the support to expose the foliage is climbing stem.
- Twinner: The weak stem itself coils around the support & climb up is known as twinner.
  Dextrose Twinner: Coiling in clockwise direction Ex: Dioscorea
  Sunistrose Twinner: Coiling in anticlockwise direction
  Ex: Bean, Clitoria
- Tendril Climber: Weak stemmed plants that climb with the help of tendrils are tendril climbers.
  Ex: Cissus, Passiflora, Vanilla, Lathyrus
- Stragglers: Woody climbers which climb up with the help of hooks or thorns are known as stragglers.
  Ex: Artabotrys, Hugonia, Bougainvillea
- Lianes: Large woody twinners that run over the top of large trees to spread the foliage are Lianes
  Ex: Gnetum, Bauhinia, Hyptage, Vintilage etc

STEM MODIFICATIONS

- When a permanent change occurs in the structure of stems of perform new functions suitable for the environment, it is known as stem modification.

- Stem modification are of three different types

I. Underground stem modifications
II. Sub –aerial stem modifications
III. Aerial stem modifications

I. **Underground Stem Modification**:

- The stems which grows below the soil are known as underground stem (Subterranean stems).
- These stems are non-green & stem nature can be identified by nodes & internodes, buds leaves & flowers
- Underground stems helps in
  a) Perennation b) Safe storage of food c) vegetative propagation
  As underground stems performs many functions they are also known as multipurpose stem modification.
- Different kinds of underground stem modifications are Rhizome, Corm, Stem tuber & bulb.

i) **Rhizome**:

- It grows horizontally beneath the soil at a particular depth
- It dorsiventral & is differenciated into nodes, internodes, scale leaves & buds
- It produces aerial branches from dorsal side & adventitious roots from ventral side
- Scale leaves are produced at each node.
- It bears axiallary & terminal buds
- Terminal buds produces aerial branches
- Axillary buds produces branches & also stores food material
- It becomes tuberous due to storage of food
- Rhizome perennate during unfavorable conditions & propagate vegetatively
  Ex: Zingiber officinalis, Curcuma longa, Musa paradisica, Canna indica
- In some grasses rhizome does not store food materials & appears thin & hard & is known as Sobole
  Ex: Carex spe

ii) **Corm**:

- It grows vertically beneath the soil
- It may be cylindrical conical or dorsiventrally flattered
- It is differenciated into node & internodes
- Scale leaves develops from the node
- It produces axillary & terminal buds
- Apical buds produces aerial shoot. Axillary buds develops into daughter corms or cormels & helps in vegetative propagation
- Special roots develops from the corm are called as contractile roots or pull roots. They help to maintain the position of corm below the soil.
- Corm is tuberous due to storage of food.
  Ex: Colocasia, Amorphophalus, Colchicum, Crocus etc

iii) **Stem Tuber**:

- It is the swollen tip of underground branch.
- Branches that develops near the ground become underground & the tips becomes tuberous due to storage of food

- It is covered by thin corky periderm
- Nodes are represented by eyes
- Eye consists of scar of scale leaf & axiallary bud. Eyes helps in vegetative propagation
  Ex: Solanum tuberosum – Stores starch
  Helianthus tuberous – Stores inulin
  Stachys tubifera - Stores stachyose

iv) **Bulb**:

- Stem is highly condensed, disc-like & does not stores the food material
- Adventitious roots develops from the ventral side of the stem & leaves develops from dorsal side of stem
- Food material is stored in the leaves
- During reproductive phase terminal bud develops into inflorescence. Daughter bulbs develops from axillary buds which helps in vegetative reproduction
- Based on the arrangement of leaves bulbs are of two types

a) **Tunicated Bulb**: Consists of foliage leaves

- Leaves are concentrically arranged.
- Leaves bases becomes fleshy due to storage of food.
- Peripheral leaf bases are dry, membranous & forms the protective covering called tunics & hence such bulb is called as tunicated bulb.
  Ex: Allium cepa (Onion)

b) **Scaly Bulb**: (Naked bulb, inbricate bulb)

- Scale leaves are present which are fleshy & overlap one another to form loose bulb.
- It is called as naked bulb as it is not covered by tunics.
  Ex: Lilium candidum
- In Allium sativum (Garlic) foliage leaves & scale leaves are present
- Scale leaves are fleshly & called as cloves
- Fleshly leaves are enclosed by white, membranous bases of foliage leaves
- This type of bud is intermediate between tunicated bulb & naked bulb

II. **Sub –Aerial Stem modifications**:

- Stem which grows just above or below the surface of soil or water are called sub-aerial stems.
- These stems helps in vegetative propagation
- Different types of sub-aerial stem modifications are Runner, Stolon, Sucker & offset

i) **Runner**:

- Long slender, prostrate stems which are rooted at each node are called as Runner
- These stems have long internodes
- Adventitious roots are produced at each node
- When internodes breaks, the nodal region develops into new plant
  Ex: Oxalis, Hydrocotyl, Marselia, Lippia, Cynadon etc

ii) **Stolon**:

- Aerial branches which produces roots wherever they come in contact with the soil are known as stolon
- These branches grows obliquely
- Roots are produced at the point of contact. These branches continue their growth & turn upward

- When these branches i.e. stolon are separated from main plant body. They develop into new plants & helps in vegetative propagation (layering)
  Ex: Nerium, Jamium, Rosa, Hibiscus, etc

ii) **Sucker**:

- It develops from the under ground part of the stem
- It grows obliquely & becomes aerial
- Roots develops from the underground part of sucker
- Later suckers develops into new plants
  Ex: Chrysanthemum, Mentha, Musa

iv) **Offset**:

- It is found in free floating hydrophytes
- It is a short, slender axillary branch with an elongated internode
- The branch bear rosette of leaves & tuft of balancing roots
- When internode breaks, offset behaves as new plant body & helps in vegetative propagation.
  Ex: Pistia, Eichhornia
- Agave americana (Xerophyte) also bears off set.

III. **Aerial Stem Modification**:

- Stem which grows above the soil are aerial stem.
- Aerial stems also undergo modifications to carryout new function.
- Some of the aerial stem modifications are ----

i) **Tendrils**:

- Long, Slender, Coiled, sensitive structures which holds the support by coiling around it is Tendril.
- Tendrils helps the weak stemmed plants to climb over the support.
- Axillary or terminal buds are modified into tendrils (stem tendrils).
  Ex: Passifora, Cissus, Vitis
  Passiflora – axillary bud develops into tendril.
  Cissus, Vitis – terminal buds develops into tendirl

ii) **Hooks**:

- Strong, woody, curved, persistant structures formed by modification of axillary or terminal buds are known as hooks.
  Ex: Hugonia – axillary bud forms hooks
  Artabotrys – terminal bud forms inflorescence & peduncle forms hook

iii) **Thorns**:

- hard, woody, pointed structures, which helps in protection & reduces transpiration are thorn.
  Ex: Bougainvillae – axillary bud forms thorn
  Carissa – terminal buds forms a pair of thorns
- In Duranta,Prunus, punica thorns bears leaves & flowers.

iv) **Phylloclade**:

- Modified, green, photosynthetic stems are phylloclade.
- Development of phylloclade is Xerophytic adaptation
- In Xerophytes leaves are reduced to spines or scales to reduce rate of transpiration. In such plants stem becomes flat, green photosynthetic structure called phylloclade
  Ex: Opuntia, Casurina, Cocoloba.

- In Opuntia, all the leaves of axillary bud forms groups of spines
- some spines are small & looks like hairs. They are known as barbs.
- Groups of barbs & spines are known as areoles.

v) **Cladode**:

- One or more short green, cylindrical or flat branches of limited growth are known as Cladode.
- It is a variation of phylloclade.
  Ex: Asparagus, Ruscus

vi) **Bulbil**:

- Modified vegetative or floral bud which stores food & helps in vegetative propagation known as bulbil.
- They are axillary in position
  Ex: Dioscorea – bulbils develops in the axil of leaves
  Agave, Globba –bulbils develops in the axil of branch
  Oxalis – group of bulbils are produced at the tip of tuberous roots at the ground level.

vii) **Tuberous Stem**:

- Aerial stem which stores the food material & becomes tuberous is known as tuberous stem.
  Ex: Brassica olerasia vargangloides (Knol – K'nol)
  Bulbophyllum, Saccharum (sugar cane)
- In Knol –K'nol, entire aerial stem becomes tuberous
- In Bulbophyllum only one internode stores food & looks like bulb which is known as pseudobulb
- In Xerophytes like Clinea & Euphorbia water is stored in the form of muscilage
- Due to this adaptation plant can survive during unfavourable conditions

LEAF

- Leaves are the lateral exogenous appendages developed from the nodes of stem.
- They have limited growth & arranged acropetally in their axils.
- Leaves grow on main stem or branches.
  Cauline leaf – develops on main stem. Ex: Palms
  Ramal leaf – develops on the branches. Ex: Neem
  Radical leaf – developing from the top of root system. Ex: Carrot
- Morphologically & anatomically, leaves exhibit more variation than stem
- Leaf characters indicate the type of natural habitat of plants
- Some Xerophytes & complete parasites (Cuscuta) do not possess leaves
- Scale leaves – Casurina
  Normal leaves – Hibiscus
- In Raphia taedigera leaf is about 22mts long & 12mts wide
- Victoria regia (hydrophyte) bears leaves which are 4mts in radius

Functions: i) Leaves carry out Photosynthesis
ii) Leaves carry out Transpiration
iii) Oxygen & Carbondioxide ratio between plant & environment is maintained by leaves.

Parts of Typical Leaf:

Leaf consists of
Leaf base ---- hypopodium
Petiole-------- mesopodium Phyllopodium (leaf)
Lamina ------ epipodium

i) Leaf base is the lowermost part of leaf.

- It helps in the attachment of leaf with the stem.
- Leaf base usually bears two lateral appendages which are known as stipules. They protect leaf & axillary bud in developing stages.
- They are prominent in dicots
- In many plants stipules falls off. Such stipules are known as deciduous stipules. Ex: Michelia
- The stipules which remain for long time are known as persistant stipules Ex: Rose
- Leaf with stipules – stipulate leaf
- Leaf without stipules – exstipulate leaf
- In most of the plants leaf base is not distinct but some time it shows different variations such as ---

a) Pulvinous leaf base: Swollen leaf base

- It helps in movements of leaf
- Seismonastic movements – movement in response to touch Ex: Mimosa pudica
- Nyctinastic movements – movements in response to light Ex: Arachis, Bean, Enterlobium

b) Sheathing leaf base: broad leaf base that surrounds the stem as an envelop is known as 'sheathing leaf base' Ex: Wheat, Sorghum, Palms

- In Musa & Canna leaf bases are concentrically arranged & forms aerial stem like structure known as pseudostem or false stem.

ii) Petiole: Stalk like structure which connects lamina to the stem is known as 'Petiole'.

- It helps to expose the lamina to the sunlight.
- It conducts water & food materials between the stem & lamina
  Petiole present – petiolate leaf
  Petiole absent – Sessile leaf
- In most of the leaves petioles are cylindrical & solid. Petioles may be hollow & tubular – fistular petoile Ex: Carica
- In some hydrophytes like Nymphaea, Petiole is attached to the lower side of lamina. Such petiole is known as 'peltate petiole'.

iii) Lamina: Green expanded part of the leaf is known as lamina or leaf blade.

- It carry out photosynthesis & transpiration.
- Lamina shows variations in shape, margin apex, Texture, Venation etc

Shape: Shape of lamina varies from plant to plant

- Acicular : needle shape—Ex: Pinus
- Linear: Long & slightly broad Ex: Grasses
- Lanceolate: Lance shaped Ex: Nerium
- Orbicular: more or less circular Ex: Lotus
- Ovate: egg shaped Ex: Hibiscus
- Elliptical: Like an ellipse Ex: Vinca rosa
- Spathulate: Spoon Shaped Ex: Euphorbia, Lippia

- Oblong: more or less rectangular Ex: Banana
- Reniform: Kidney shaped Ex: Hydrocotyle.
- Cordate: heart shaped, deep notch at the base Ex: Betel vine
- Saggitate: Shaped like an arrow head Ex: Saggitaria
- Hastate: Like saggitate leaf but lobes are directed outwards Ex: Ipomoea
- Lyrate: Shaped like a lyre Ex: Mustard
- Cunate: Wedge shaped Ex: Pistia
- Centric: Hollow & Cylindrical Ex: Oricon

Margin of Lamina:
- Entire: Smooth margin Ex: Mango
- Serrate: Saw like margin Ex: Neem, Rose
- Dentate: Large pointed teeth like margin Ex: Tridax, Hibiscus
- Crenate: margin with round teeth Ex: Bryophyllum
- Repend: Wavy margin Ex: Polyalthia.
- Spiny: margin with spines Ex: Argemone.

Leaf Apex:
- Acute: narrow, pointed apex Ex: Mango
- Acuminate: apex is narrow, long like tapering tail Ex: Ficus religiosa
- Obtuse: round apex Ex: Banyan
- Mucronate: round with apex with pointed tip Ex: Vinca rosa
- Cuspidate: spinous apex Ex: Date palm
- Tendrillar: apex forms tendril Ex: Gloriosa
- Truncate: apex is abruptly cut across Ex: Paris polyphylla
- Retuse: Obtuse apex with slight notch Ex: Pistia
- Emarginate: obtuse apex with deep notch Ex: Bauhinia

Surface of Lamina:
- Glabrous: smooth without hairs Ex: Mangifera
- Glaucus: covered with waxy coating with white tinge Ex: Calotropis
- Scabous: rough surface Ex: Ficus
- Viscous: sticky surface Ex: Cleome
- Pubescent: covered with soft hairs Ex: Tomato
- Hispid: covered with long rigid hairs Ex: Cucurbita
- Spinous: covered with small spines Ex: Solanum

Texture of Lamina:
- Herbaceous: Thin & soft lamina
- Coriaceous: Leathery lamina
- Succulent: thick, soft, juicy lamina
- Hygroscopic: thin, membranous spongy lamina

Venation: “The arrangement of veins in the lamina is known as Venation”.
- Veins are the hard structures consisting of vascular bundles
- Veins give mechanical strength & shape to lamina
- They helps in conduction of water, mineral & organic food materials

Types of Venation: Angiosperms exhibits two types of venation

i) Reticulate venation   ii) Parallel venation

i) **Reticulate venation**:
- In this type lamina is provided with midrib.
- Many lateral veins are produced from midrib.

- Lateral veins divides & redivides & form veinlets which forms reticulum or network.
- It is commonly found in dicots, but some monocots like Smilax & Dioscorea show reticulate venation
- Based on number of midveins reticulate venation is of 2 types---
  a) Pinnate reticulate venation/Unicostate reticulate venation
  b) Palmate reticulate venation/Multicostate reticulate venation

a) **Pinnnate Reticulate Venation**:

- It is characterised by the presence of single prominent midrib.
- Midrib produces lateral veins on either side
- Lateral veins produces veinlets which are arranged in the form of reticulum
- Because of the presence of single prominent midrib, this type of venation is also known as unicostate reticulate venation.
  Ex: Hibiscus, Mangifera

b) **Palmate Reticulate Venation**:

- More than one prominent veins arises from the base of Lamina
- They divided repeatedly & form branches which spread out as fingers on the palm.
- Because of the presence of more than one prominent mid vein, this type of venation is also known as multicostate reticulate venation
- It is of two types----

Convergent type
Prominent veins run thro out, the lamina & converge at its apex.
Ex: Ziziphus, Cinnamomum.

Divergent type
Lamina is palmate lobed.
Prominent veins spread out & ends differently in each lobe.
(different directions)
Ex: Ricinus, Cucurbita

ii) **Parallel Venation**:

- In this type veins & veinlets run parallel to each other
- It is common in monocots, but few dicots like Callophyllum & Eryngium shows parallel venation.
- Parallel venation is of two types
  a) Pinnate parallel venation/Unicostate parallel venation
  b) Palmate parallel venation/Multicostate parallel venation

a) **Pinnate parallel venation**:

- Lamina shows strong midrib.
- Midrib produces lateral vein on either side
- Lateral veins divides & redivides to form veinlets which shows parallel arrangement.
- Because of the presence of single prominent mid rib venation is also known as Unicostate parallel venation. Ex: Banana, Canna

b) **Palmate parallel venation**:

- more than one prominent veins arises from the base of lamina

- They produce branches which are parallely arranged.
- Because of the presence of many prominent veins it is also known as multicostate parallel venation
- It is of two types ----

Convergent type	Divergent type
Lamina unlobed	Lamina is lobed
Parallel veins runs thro' out lamina & converged at the apex Ex: Bamboo, Grasses, Paddy etc	Prominent veins spread out differently in different lobes Ex: Borassus

Types of Leaves: Based on lamina leaves are classified into
i) simple leaves ii) compound leave

i) **Simple leaves**:
- In this type petiole bears single, undivided lamina.
- Simple leaf may be entire Ex: Mango, Hibiscus
- It may be lobed. The lobes may be ---
  pinnately arranged Ex: Brassica
  palmately arranged Ex: Gossypium Passiflora

ii) **Compound Leaf**:
- In this type, the lamina is completely dissected into segments or units called leaflets or pinnas.
- The axis of compound leaf is called as rachis.
- Compound leaves are of 2 types ----
  a) Pinnate compound leaf
  b) Palmate compound leaf

a) Pinnate compound leaf:
- In this type leaflets develops on either side of rachis or its branch.
- Leaflets may be arranged in pairs. Such type of pinnate compound leaf is known as paripinnate Ex: Tamarindus
- When unpair leaflet is present at the apex of rachis, it is known as imparpinnate. Ex: Rose, Neem
- Pinnate compound leaf is again sub-divided into ----

1) Unipinnate compound leaf:
- Primary rachis is unbranched & bears leaflets on either side. Ex: Tamarindus, Rosa, Neem etc

2) Bipinnnate Compound leaf:
- Primary rachis produce secondary rachii. Leaflets develops on secondary rachis Ex: Acaccia, Delonix

3) Tripinate compound leaf:
- Primary rachis produce secondary rachii which inturn produces tertiary rachii.
- Leaflets develops on tertiary rachis
  Ex: Moringa, Millingtonia

4) Decompound leaf:
- Primary rachis divides repeated without any definite order.
- Lamina is dissected & is arranged on terminal rachii Ex: Coriandrum

b) Palmate compound leaf:

- In this type, the leaflets are arranged at the tip of petiole
- Based on the number of leaflets, palmate compound leaves are sub-divided into---

1) Unifoliate compound leaf:
- compound leaf with single leaflet at tip of petiole Ex: Citrus

2) Bifoliate compound leaf:
- Two leaflets develops at the tip of petiole
  Ex: Balanitis, Zornia, Hardwickia

3) Trifoliate compound leaf:
- Three leaflets develops at the tip of petiole
  Ex: Dolichos, Oxalis

4) Tetrapoliate compound leaf:
- Four leaflets develops at the tip of petiole
  Ex: Marsilea

5) Pentafoliate compound leaf:
- Five leaflets at the tip of petiole
  Ex: Gynandropis

6) Multifoliate compound leaf:
- More than five leaflets at the tip of petiole
  Ex: Ceiba pentandra

Phyllotaxy:
- Mode of arrangement of leaves on the stem or branch is known as phyllotaxy
- The main objective of phyllotaxy is to avoid over shading among leaves so that all the leaves are well exposed to sunlight
- It is genetically controlled phenomenon
- Depending upon the number of leaves at each node, phyllotaxy is of different types---

i) Alternate /Spiral Phyllotaxy:
- Only one leaf arises at each node
- Leaves present at successive nodes alternate with each other
- If an imaginary line is drawn connecting all the leaf bases, it appears spiral
- The term 'genetic spiral' may be used to describe such imaginary spiral line.
- In spiral phyllotaxy, leaves are arranged on stem in regular vertical rows. Such rows are known as Orthostiches.
- Based on the number of orthostiches, spiral phyllotaxy may be ----

a) Distichous – two rows of leaves are present
   Ex: Annona, Cynodon
b) Tristichous – three rows of leaves are present
   Ex: Cyperus rotundus
c) Pentastichous – five rows of leaves are present
   Ex: China rose, Banyan
d) Octastichous – 8 rows of leaves are present
   Ex: Carica Papaya

ii) Opposite Phyllotaxy:
- When two leavers are present at a node opposite to one another, the type of phyllotaxy is called opposite

- It is of two types ----

Opposite decussate	Opposite superposed
opposite leaves at successive nodes are at right angle to each other	opposite leaves at successive nodes are arranged on above the other
Ex: Calotropis	Ex: Quisqualis

iii) Whorled Phyllotaxy: In this type

- More than two leaves develop at each node.
- it is also called as cyclic or verticellate phyllotaxy
  Ex: Hydrilla, Nerium, Alstonia etc

iv) Leaf Mosaic:

- It is special type of arrangement of leaves.
- Older leaves present at lower nodes bear longer petioles & young leaves of upper nodes bear short petioles
- Young leaves occupy the space present between the older leaves
- Such arrangement of leaves is helpful to expose all the leaves to sunlight
  Ex: Acalypha, Begonia

Heterophylly:

- Development of different kinds of leaves at different nodes of a plant is known as heterophylly
- It is of three types ----

i) Environmental / Ecological heterophylly
ii) Developmental Heterophylly
iii) Habitual Heterophylly

i) Environmental / Ecological Heterophylly:

- Formation of different of kinds of leaves at different nodes of a plant in response to surrounding environmental is known as environmental heterophylly.
- It is mostly seen in Hydrophytes Ex: Limnophylla, Ranunculus
- In these plant submerged leaves are dissected & root like where as aerial leaves are more or less entire.

ii) Developmental Heterophylly:

- In some plants, different kinds of leaves are produced at different developmental stages & hence it is known as developmental heterophylly.
- In Dolichos lab lab, simple leaves are produced in seedling stage which are replaced by trifoliate compound leaves in mature plant
- In Acacia melanoxylon, bipinnate compound leaves are produced in young plants but as the plant grows older leaves are represented by phyllodes.

iii) Habitual Heterophylly:

- In this case, the plant produces different types of leaves right from the begining
- In Artocarpus, leaves are simple & entire. But many leaves with lobed nature also appears at different nodes.
- Selaginella also shows habitual heterophylly.

LEAF MODIFICATIONS

- Leaves are inflenced by environmental conditions & hence show modification to carryout new functions
- Normal functions of leaves are photosynthesis & transpiration
- Entire leaf or a part of leaf undergoes permanent change to perform newfunctions suitable for the environment

Some important modifications are ----

1. **Leaf Tendril**:

- Long, wiry, slender, sensitive structures which coils around the support are known as tendrils
- In weak stemmed plants entire leaf or a part of the leaf is modified to tendril – leaf tendril

Example	Part modified
Lathyrus	Entire leaf
Pisum	Terminal leaflets
Nepenthes	Part of petiole
Gloriosa	Leaf tip
Smilax	Stipules
Clematis	Petiole

2. **Spines**:

- Spine is a stiff, pointed structure formed by the modification of entire leaf or a plant of leaf.
- Development of spine is a Xerophytic character
- They help to reduce transpiration rate & also protects the plant herbivores.

Example	Part modified
Opuntia	All leaves of axillary branch
Citrus	Ist leaves of axillary branch
Acacia, Zizyphus Parkinsonia	Stipules
Yucca, Phoenix Aloe, Agare	Leaf tip
Argemone, Aloe	Leaf margin

- Groups of spines that develops on the phylloclade of pountia are called areoles or tubercles.

3. **Scale leaves**:

- Scale leaves are membranous, non-green structures formed by the reduction of foliage leaves
- Leaves are modified into scale to reduce transpiration Ex: Casurina
- Scale leaves protect axillary buds Ex: Zingiber
- The store food & become fleshy Ex: Cilium, Garlic
- They are also found in complete parasites like Balanophora & Orobanche

4. **Phyllode**:

- Green, expanded, photosynthetic structure formed by the modification of petiole or rachis is known as phyllode
- Development of phyllode is Xerophytic adaptation.
- In Xerophytes leaves are reduced the rate of transpiration. In such case petiole or rachis forms phyllode which carryout photosynthesis.
  Ex: Acacia melanoxylon – petiole form phyllode

Parkinsonia – secondary rachis forms phyllode
Nepenthes – Leaf base forms phyllode

5. **Reproductive leaves**:

- Buds produced on leaves are known as epiphyllous
- These buds helps in vegetative propagation
- Leaves bearing epiphyllous buds are known as reproductive leaves
  Ex: Bryophyllum – buds develops on margins
  Begonia – buds develops from injured part of leaf
  Scilla – buds develops at the tip of leaf

6. **Storage leaves**:

- Leaves which stores food material or water & becomes fleshy are known as storage leaves.
- They are also known as succulent leaves.
  Ex: Aloe, Kalanchoe, Peperomia, Allium, Cabbage
- Special parenchyma of leaves stores food of water.
- Onion, Garlic, Cilium & Cabbage – stores food in leaves
- Aloe, Bryophyllum, Begonia – stores water in leaves in the form of mucilage

7. **Absorbing leaves**:

- Leaves which are absorb water & minerals are called as absorbing leaves.
- They are found in hydrophytes.
- These roots are dissected & look like root
  Ex: Limnophila, Utriculara, Salvinice

8. **Trap leaves**: (Carnivorous or insectivorous leaves plants having tap leaves grows in nitrogen deficient soils (boggy soils)

- These leaves secrete protedlytic enzymes that can digest insect protein. Thus trap leaves helps in supplementing nutrition.
  Ex: Nepenthes, Drosera, Dionea, Utricularia

a) **Drosera**: (Sundew plant) is a small terrestrial herb.

- Lamina is spathulate.
- Margin is provided with glandular tentacles.
- Tentacles secrete sticky fluid/ digestive juice at their tips which shines like a dew drop
- When insect visit the live, it gets adhered to leaf
- Tentacles bend & covers the insect, & digestive juice digest the insect protein.

b) **Nepenthes**: (Pitcher plant) It forms in Assam forest

- Lamina is modified to hollow pitcher. Inner surface is provided with hairs which and directed downward.
- Lower part of petiole (leaf base) is modified into wing like phyllode.
- Upper part of petiole is modified to tendrill
- Leaf apex is modified into immovable lid.
- rim of the pitcher is lined with nectar glands
- the hairs prevents the insect to escape out.
- bottom of pitcher is filled with watery fluid which is acidic
- Lid is attractive
- The pitcher acts as trap for insects. Which are killed & digested for nitrogenous matter.

c) **Dionea**: (Venus fly trap) It is marsh herb found in USA

- Petiole is modified into wing like structure

- mid rid acts as hinge & Lamina halves can be opened & closed like a book
- Upper surface of leaves is provided with digestive glands & sensitive hairs
- When the insect body comes in contact with sensitive hairs, sudden closure of leaf occur & digested by the leaf.

d) **<u>Utricularia</u>** (Bladder wort)

- It is a root less, submerged hydrophyte
- Lamina is dissected into narrow root like segments
- Some of the segments are modified into bladder like structure
- Mouth of bladder is provided with trap doors & bristles
- Protozoans or insect larvae present in water enter into the trap thro trap doors.
- The animals collected in the bladder are killed & digested.
- Epiphytic climber Dischidia rafflesiana shows pitcher formed by modification of leaves. These pitches do not catch insects but holds water.

1) <u>INFLORESCENCE</u>

- Reproductive shoot bearing flowers is called as inflorescence (or) Mode of development & arrangement of flower on peduncle is called as inflorescence.
- Inflorescence is a group of flowers on common axis
- The axis bearing flowers is known as peduncle.
- The stalk of individual flower is known as pedicel.
- The arrangement of flowers on the peduncle is known as anthotaxy.
- Presence of flowers is the characteristic feature of angiosperms

A) **<u>Types of Inflorescence based on origin</u>**:

Terminal inflorescence	Axillary inflorescence	Intercalary inflorescence
Inflorescence present at the apex of main	Inflorescence develop in the axils of leaves	Inflorescence borne at the internodes in between the leaves
Ex: Crotolaria , Croton	Ex: Hibiscus, Dolichos	Ex: Callistemon

- Development of flowers directly on the older stem is known as cauliflory.
  Ex: Theobroma, Polyalthia, Artocarpus, Couropita etc.

B) **<u>Types of inflorescence based on growth & development of peduncle & arrangement of flowers</u>:**

- Inflorescence is classified into 3 types -----
  I) Racemose inflorescence
  II) Cymose inflorescence
  III) Specialty

I) **<u>Racemose Inflorescence</u>**:

- It is also called as indefinite or indeterminate type
- The characters of racemose inflorescennce are ----
  a) Indefinite growth of peduncle
  b) More or indefinite number of flowers
  c) Flowers arranged in acropetal succession

d) Flowers open in centripetal succession i.e opening of flowers proceeds from periphery to centre.

e) Peduncle may be branched (simple type) or unbranched (compound type)

- Based on the presence & absence of pedicel racemose inflorescence is of two type ---

with pedicellate flowers	with sellile flowers
1.Simple raceme	1.Simple spike
2.Compound raceme	2. Compound spike
3. Simple corymb	3. Simple spadix
4. Compound corymb	4. Compound spadix
5. Simple umbel	5. Simple Head
6. Compound umbel	6. Compound Head
	7. Catkin

A) **<u>Racemose Inflorescence with Pedicellate flowers</u>**:

1) <u>Simple Raceme</u>:
- Peduncle is long, unbranched & grows indefinitely
- Many bracteate, pedicellate flowers are arranged in acropetal succession.
  Ex: Crotolaria, Tamarindus, Dolichos etc.

2) <u>Compound Raceme (or) Panicle</u>:
- Penducle is branched
- each branch produce bracteate, pedicellate flowers in acropetal succession
- each branch resembles simple raceme
  Ex: Mangifera, Yucca, Azadirachta, Nicotiana etc.

3) <u>Simple Corymb</u>:
- Peduncle is unbranched & grows indefinitely
- Penducle is slightly condensed.
- Many bracteate, pedicellate flowers are arranged in acropetal succession.
- Older flowers have longer pedicels, younger flowers have shorter pedicels & hence all the flowers are at the same level.
  Ex: Delonix, Iberis, Gynandropis, Cassia etc

4) <u>Compound Corymb</u>:
- Peduncle is branched
- each branch resembles simple corymb.
  Ex: Pyrus malus, Brassica oleracea var. botrytis (Cauliflower)
- In cauliflower inflorescence stores food material

5) <u>Simple Umbel</u>:
- Peduncle is unbranches & grows indefinitely
- Peduncle is condensed
- Many bracteate, pedicellate flowers arrises from the tip of the peduncle
- Bracts froms involuore which protects young inflorescence
- flowers opens in centripetal manner.
  Ex: Allium cepa, Crinum etc

6) <u>Compound Umbel</u>:
- Peduncle is branched
- Branches develops in umbellate manner.
- Each branch produce simple umbel at its tip
- Whorl of bracts present at the base of branches is known as involucre

- Whorl of bracts that surrounds the flowers is known as involucel.
- It is the characteristic type inflorescence seen in members of Umbelliferae
  Ex: Coriandrum, Foeniculum, Carum Dancus carota.

B) **Racemose Inflorescence with Sessile flowers**:

1) Simple spike:

- Peduncle is unbranched & grows indefinitely
- Numerous, bracteate, sessile flowers are arranged in acropetal succession.
  Ex: Achyranthes, Amaranthus, Polyanthes (lily) Digeria, Pupalia etc.

2) Compound spike:

- Peduncle is branched
- Each branch produce bracteate, sessile flower acropetally & are known as spikelets
- Axis of spikelets is known as rachille.
- Lower bracts are sterile as flowers are not produced in their axils.
- Upper bracts are fertile as they bear flowers in their axil.
- Lower sterile bracts – glumes
- Upper sterile bracts – lemma
- Bracteoles are known as palae
- Perianth lobes are reduced known as lodicules
- Essential organs develop above the lodicules
- It is the characteristic feature of Poaceae
  Ex: Oryza sativa, Sorghum, Triticum, Zea mays etc

3) Catkin (or) Amentum:

- Penducle is unbranched & grows indefinitely
- Penducle is weak & drooping
- Numerous, sersile unisexual flowers develops in acropetal succession.
- Inflorescence hangs down as peduncle is weak
- It is seen in members of Amentiferae & hence also known as amentum
- Staminate inflorescence shed as a unit after the dehiscence of Pollen
  Ex: Acalypha, Casurina, Betula, Morus alba etc

4) Simple spadix:

- Penducle is thick, fleshly, unbranched & grows indefinitely
- Unisexual sessile, bracteate flowers develops acropetally.
- Female flowers are at the base & male flowers towards the apex.
- Terminal part of peduncle is flowerless & is known as appendix.
- Inflorescence is covered by enlarged bract called spathe.
- Spadix is commonly seen in Aroidae (Araceae)
  Ex: Colocasia, Alocasia, Arum, Typhonium etc.
- Largest spadix is seen in Amorphophallus
- Smallest spadix is seen in Lemnaceae
- In between male & female flowers neutral flowers are present.

5) Compound spadix:

- Peduncle is branched & shows indefinite growth
- Each branch resembles simple spadix
- Spathe may be leathery or woody
- In Cocos, inflorescence is covered by woody boat shaped spathe.
- In Musa, inflorescence is covered by leathery spathe.

6) Head (or) Capitulum (or) Anthodium:

- It is highly evolved among racemose type
- It is the characteristic feature of Asteraceae
- Peduncle is highly condensed, disc like & is known as receptacle.
- Numerous, sessile florets develops compactly over discoid peduncle & are surrounded by involuore of bracts
- Florets are of two types. They are ray florets & disc florets
- Ray florets are female, zygomorphic & peripheral
- Disc florets are bisexual ,actinomorphic & central
- Head is of two types –

Homogamous head	Heterogamous head
Head with one type of florets	Head with two types of florets
Ex: Vernonia, Notonia } all disc florets	ray florets at the periphery & disc florets at the centre
Zinnia, Chrysanthemum } all ray florets	Ex: Sunflower, Tridax

7) <u>Compound Head</u>:

- Peduncle is branched
- Each branch bears simple head
  Ex: Echinops, Spheranthus

<u>Advanced features of Head inflorescence</u>:

- Head inflorescence is highly advanced as it shows following features ----
  i) Economy of biological material
  ii) Close aggregation of florets enhances the attraction
  iii) Maximum polection of florets is ensured
  iv) Single visit of insect pollinate many florets at a time
  v) Seed output is more

II) **<u>Cymose Inflorescence</u>**:

- also known as definite or determinate type
- cymose inflorescence shows following characters
  a) definite growth of peduncle
  b) limited number of flowers
  c) flowers arranged in basipetal succession
  d) flowers open in centrifugal manner i.e. flowers opens from centre to periphery
  e) Peduncle may be branched or unbranched
- Different types of cymose inflorescence are ----
  1) <u>Solitary Cyme</u>:
- Inflorescence consists of single flower
- Peduncle ends in single flower
- It may be axillary or terminal in position
  Ex: Hibiscus – axillary
  Datura – terminal
  2) <u>Simple Cyme (or) Cymule</u>:
- Growth of peduncle is definite & terminate with flower
- below the terminal flower, two lateral branches develop in the axial of opposite leaves

- These branches also ends in a flower
- Hence simple cyme consists of 3 flowers
- Flowers opens in centrifugal manner
  Ex: Jasmium , Bougainvillea
- In Bougainvillea, bracts are large & pataloid
  3) <u>Monochasial cyme</u>:
- Peduncle shows definite growth & terminate with flower
- Below this flower only one lateral branch develops which also ends in a flower
- The same process is repeated
- Since only one branch develops below each flower it is known as monochasial cyme
- It is of two types -----

Helocoid cyme
all successive flowers
bearing lateral branches
are produced on same
on
side
Ex: Hamelia
Begonia

Scorpoid cyme
all successive flowers
bearing lateral branches
are produced alternate
both sides in a zig-zag
manner
Ex: Heliotropium
Solanum (Bringal)

4) <u>Dichasial cyme</u>:
- Peduncle is definite & terminate with flower
- Below the flower two lateral branches develop
- These branches also terminate with flower
- Same type of growth continues further
  Ex: Clerodendron, Ixora, Jatropa, Ipomoea
  5) <u>Polychasial cyme</u>:
- Peduncle is definite & terminate with flower
- More than two lateral branches develops below the terminal flower, which also ends with flower.
- Same growth is continued
  Ex: Nerium, Plumeria

III) **<u>Special Types of Inflorescence</u>**:
- In some inflorescence the arrangement & opening of flowers is peculiar & hence they are described as special type
- Different type of special inflorescence are -----
  1) Verticillaster 2) Cyathium 3) Hypanthodium
  1) <u>Verticillaster</u>: (Glomerule)
- The name verticillaster is derived from 'vertical' i.e. false whorl
- Two dichasial cymes arises in the axial of opposite leaves.
- Its branches grows further in monochasial scorpoid manner.
- Two inflorescence forms 'false whorl' around the node
- It looks like a single ball-like inflorescence & hence known as verticullaster
- It is found in lamiaceae members Ex: leucas, leonotis
  2) <u>Cyathium</u>:

- It is highly reduced & looks like single flower
- Seen in members of Euphorbiaceae
- Involuore of bracts fuse to deep up-like structure
- Nectaries are present at the rim of involuore
- Unisexual, achlamydous flowers develops in the cup
- Single female flower develops from the centre, represented by tricarpellary, syncarpous superior ovary
- Many male flowers surrounds the female flower
- Male flowers are arranged in scorpoid manner
- Flowers opens in centrifugal manner

  Ex: Poinsettia, Euphorbia

  3) Hypanthodium:
- It is fruit like inflorescence
- Peduncle is fleshy & forms hollow cup like structure with apical opening known as 'orifice'.
- Three types of flowers develops on inner surface of peduncle
- Female flowers are towards the base & male flowers are towards the orifice
- Gall flowers (sterile female flowers) are present between male & female flowers
- It is seen in members of Moraceae Ex: Ficus Sps
- The inflorescence is pollinated by a gall wasp (Blastophoga)

FLOWER

- Flower is modified reproductive shoot.
- It carryout sexual reproduction
- Reproductive leaves present in flower are called sporophylls
- Linnaeus, Bauhin, Gosthe & de Candole describe flower as modified shoot

Parts of a Typical Flower:

- Flower arises in the axial of leaf
- Stalk of the flower is known as pedicel
- apical part of pedicel is known as receptacal or torus or thalamus
- Internodes of thalamus are highly condensed
- Thalamus has 4 nodes & 3 internodes

- Parts of flower ----

Non –essential organs ↓ Perianth
- Calyx (sepals)
- Corolla (petals)

Essential organs ↓ Sporophylls
- Androecium (stamens)
- Gynorcium (carpels)

Calyx:

- It is the outermost whorl of flower
- unit of calyx is sepal
- sepals are green in colour

- calyx give protection to the flower when it is in bud condition

Corolla:

- It is second whorl of flower
- unit of corolla is petal
- petals are brightly coloured & attract insects
- calyx & corolla are known as non-essential organs as they are not involved directly in sexual reproduction
- They are together known as perianth Unit of periant is tepal

Androecium:

- It is third whorl of flower
- Its unit is known as stamen
- It is male reproductive organ of flower

Gynoecium:

- It is fourth whorl of flower
- Its unit is known as carpel
- It is female reproductive organ of flower
- Androecum & Gynoecium are known as essential organs as they are directly involved in sexual reproduction

Description of a flower:

- Bracteate: if the flower has bract, it is bracteate
- Ebracteate: if bract is absent, it is ebracteate
- Anterior side: side of flower facing bract
- Posterior side: side of flower facing mother axis
- Bracteolate: bracteoles are present
- Ebracteolate: bracteoles are absent
- Pedicelate: flower with pedicel
- Sessile: flower without pedicel
- Complete: flower having all floral leaves
- Incomplete: flower without one or more floral leaves
  Ex: Achlamydous flower – Euphorbia sps
- Apetalous: flowers without petals Ex: Soneratia apetala
- Unisexual : flower have either androecium or gynoecium
  Ex: Cocos, Riunus
- Staminate (or) Male flowers: flowers having only androecium
- Pistillate (or) female flowers: flower having only gynoecium

Sex Distribution: based on sexuality, plants are of 3 types

Monoecious	Dioecious	Polygamous
male & female flowers on same plant	male & female flowers on different plants	unisexual & bisexual flowers on same plant
Ex:Cocos, Ricinus Colocasia,Acalypha	Ex: Vallisneria, Cycas, Carica Borasus	Ex: Mangifera, Polygonum, Diosphyros

Symmetry of Flower: Based on the arrangement, number & structure of floral organs, symmetry is of different types

A) Symmetry Based on arrangement: Based on arrangement flowers are of 3 different types ----
   a) Acyclic/Spiral: floral parts are spirally arranged on the thalamus Ex: Magnolia
   b) Cyclic: floral parts are arranged in circles on the thalamus Ex: Hibiscus, Datura, Dolichos
   c) Hemicyclic/Spirocyclic: perianth members are arranged in cycles & essential organs are arranged spirally. Ex: Annona, Polyalthia

B) Symmetry Based on Number: (Merosity)

- number of floral parts in each whorl of flower is known as merosity.
- Merosity is of different types
  a) Isomerous: each whorl of flower have same number of floral organs
     Ex: Trimerous – 3 parts in each whorl Ex: Allium
     Tetramerous – 4 parts in each whorl Ex: Brassica
     Pentamerous – 5 parts in each whorl Ex: Hibiscus
  b) Anisomerous: (heteromerous): each whorl of flower have different number of floral parts.
     Ex: Ocimum – Sepals = 5, Petals = 5
     Stamens = 4, Carpels = 2

C) Symmetry Based on Structure: Different types of flowers based on structure are ---
   b) Actinomorphic/Regular flowers:
      - flowers can be divided into two equal halves in any vertical plane.
      - These flowers are radically symmetrical
      Ex: Hibiscus, Allium
   b) Zygomorphic/Irregular flowers:
      - flowers can be divided into two equal halves in only one vertical plane
      - flowers are bilateral symmetry Ex: Dolichos, Crotolaria
   c) Asymmetric flowers:
      - flowers can't be divided into equal halves in any vertical plane
        Ex: Canna

Types of flowers on position of Gynoecium on the thalamus: Based on position of gynoecium on thalamus 3 types of flowers are there ----

1) Hypogynous:
   - Thalamus is flat, conical or convex
   - gynoecium is at the apex of Thalamus
   - other floral organs develops from base of the ovary as a result ovary becomes superior
     Ex: Annona, Datura, Polyathia, Hibiscus
2) Perigynous:
   - Thalamus is concave or saucer shaped
   - gynoecium is situated at the centre of thalamus
   - other floral parts develops from the rim of the thalamus as a result ovary becomes half superior or half inferior
     Ex: Crotolaria, Bean, Cassia, Tephrosia etc
3) Epigynous:
   - Thalamus is deep cup-shaped
   - ovary is embeded in the thalamus
   - ovary wall & Thalamus are fused

- other floral parts arises from the rim of thalamus above the level of ovary, ovary becomes inferior
  Ex: Tridax, Cucumis, Musa, Psidium

Deltailed Description of Flower:

Bract (Hypsophyll)

- flower bearing reduced leaf is known as bract
- flowers develops in the axil of bract
- They protects the flower buds
- Small scale like structures present on the pedicel are known as bracteole

Variations of Bracts: Bracts shows many variations from their normal structure

1) Foliaceous /Leaf like bract: green expanded, leaf like bracts
   Ex: Lathyrus, Pisum, Gynandropis, Adrathoda
2) Petaloid Bract: Brightly coloured, attractive, petal like bracts
   Ex: Bougamvillae, Poinsettia
3) Involucre: Whorl of bracts which protect the inflorescence
   Ex: Tridax, Coriandrum, Helianthus
4) Glumes: Sterile bracts present on rachilla of spikelet. Ex: Oryza
5) Lemma: Fertile bracts present on rachilla Ex: Oryza
6) Spathe: Enlarged bract that covers inflorescence
   Ex: Cocos, Musa, Alocasia etc

Thalamus (or) Receptacle (or) Torus:

- Swollen apical part of the pedicel is thalamus
- Internodes are condensed

1) Anthophore: Stalk that bears corolla
   - Elongated internode between calyx & corolla
     Ex: Lychnis & Silene
2) Androphore:
   - Elongated internode internode present between corolla & androecium
     Ex: Gynandropis
3) Gynophore: elongated internode present between androecium & gynoecium
   Ex: Gynandropis, Capparis
4) Gynandrophore: elongated internodes present between essential & non essential organs Ex: Passiflora
5) Carpophore: It is formed due to extension of Thalamus between the carpeles
   Ex: Coriandrum, Foeniculum, Geranium
6) Gynobase: enlargement of Thalamus blow the gynoecium. It contains nectaric glands. Ex: Citrus, Mangifera

Perianth (Non –essential organs):

- Calyx & corolla together called as perianth
- They protect essential organs & indirectly helps in sexual reproduction
- Perianth is absent – achlamydous flowers
- Perianth is present – chlamydous flowers

Monochlamydous flowers
- perianth in one whorl
Ex: Ricinus, Croton, Amaranthus

Dichlamydous flowers
- perianth in two whorls

Homochalamydous flowers
- perianth members of outer & inner whorl is similar in all respect

Ex: Allium,Yucca Michelia & most of monocots

Heterochlamydous flowers
- outer & inner whorl of perianth are dissimilar
- outer whorl = sepals
- inner whorl = petals

Ex: Most of dicots (Hibiscus, Datura Crotolaria, Dolichos)

Aestivation: "Arrangement of Perianth members in bud condition is known as aestivation".

- Different types of aestivation are ----

1) Open: margins of perianth members are free with wide gaps between them
Ex: Calyx in Brassicaceae

2) Valvate: margins of perianth members are closely arranged with small gaps between them.

- They may be free or fused
Ex: Calyx of Hibiscus, Datura, Crotolaria

3) Twisted or Contored: Perianth members overlap one another i.e. one margin of perianth lobe is overlapped by the other perianth membrane.

- in all the perianth members one margin is inside & the other margin is outside.
Ex: Corolla of Hibiscus, Datura

4) Imbricate: Out of 5 perianth members of a whorl, one is completely inside & the other is completely outside. The remaining three members shows regular overlapping.

- It is of two types ----

a) Ascending imbricate: Ex: Corolla of Caesalpinaceae

- Odd petal (posterior) is completely inside & one of the anterior petal is completely outside.
- Remaining three petals shows regular overlapping
- Overlapping proceeds upwards (antero.posterior)

b) Descending imbricate: Ex: Corolla of fabaceae

- Odd petal is posterior & completely outside
- Anterior pair of petals are completely inside
- Each of lateral 2 petals have anterior margin outside & posterior margin inside
- Overlaping proceeds downwards i.e. posterio anterior

5) Quincuncial: Out of 5 perianth members, 2 are completely outside, 2 are completely inside, remaining one petal has one margin inside & one margin outside
Ex: Calyx of Thevelia, Catheranthus (Vinca)

Calyx:

- It is the outermost whorl of flower & consists of sepals
- Sepals are usually green & protect other floral leaves in bud condition
- Sepals may be free or fused
  sepals free – Polysepalous Ex: Cassia, Polyalthia
  sepals fused – gamosepalous Ex: Datura, Hibiscus
- Sepals may be deciduous i.e. falls soon after the process of fertilization
- Sepals may be persistant i.e. longlasting
- They remain even after fruit formation
- Marcescent calyx –persistant calyx which does not grows further along with the fruit Ex: Tomato, Chillies
- Acrescent calyx – persistant calyx which grows further along with fruits Ex: Brinjal, Physalis
- Variation of Calyx:

i) Petaloid: "enlarged, brightly coloured sepals which resembles petals".
Ex: Clerodendron, Mussaenda, Saraca, Tamarindus

- Petaloid sepals are called as advertising flag

ii) Pappus: sepals are reduced & modified into hairs

- It helps in fruit dispersal Ex: Tridax

iii) Succulent: fleshy & juicy sepals
Ex: Dillenia → fleshy sepals contain much acid & mucilage & are edible
iv) Hooded: sepal is enlarged & form hood over the flower Ex: Aconitum

Corolla:

- It is the second whorl of flower & consists of brightly coloured petals
- Petals attracts the insects & helps in pollination
- Corolla is described as ----
  Apetalous – petals absent
  Polypetalous – petals free
  gamopetalous – petals fused

Forms of Corolla:

A.Polypetalous Corolla:
1) Cruciform: four clawed petals arranged in the form of cross Ex: Mustard
2) Rosaceous: five free sessile petals with lobes spreding outwards
Ex: Rose, Hibiscus
3) Caryophyllaceous: five free clawed petals with limbs at right angle to claw
Ex: Diantheis
4) Papilionaceous: five free unequal petals arranged in a definite fashion.
Posterior petal is largest & known as standard (vaxillum), on either side of standard, two lateral wings (alae) & remaining two anterior petals unite to form boat shaped keel or carina. Keel petals encloses essential organs
Ex: Fabaceae members

B.Gamopetalous Corolla:
1) Tubular: 5 fused petals forms a tube like structure
Ex: Disc florets of Asteraceae
2) Infundibuliform: funnel shaped corolla Ex: Datura
3) Companulate: bell shaped corolla Ex: Tevetia
4) Rotate: short tubular wheel shaped corolla Ex: Bringal
5) Hypocraterform: Salver shaped corolla. It is provided with elongated narrow tube having lobes at the top placed at right angles Ex: Vinca
6) Ligulate: Tongue shaped corolla Ex: Ray florets of Asteraceae

7) Bilabiate: Corolla united in such a way that it appears two lipped.
Ex: Labiatae members (leucas)

Corona: "Brightly coloured structures developed over the petals to increase the attraction of flower". Ex: Passiflora, Nerium , Thevetia

Androecium: It is the male reproductive organ.

- It is the 3rd whorl of flower
- It consists of stamens which are morphologically equal to micro sporophylls
- fertile stamens produce pollen grains
- Sterile stamens are known as staminodes
  Ex: Cassia
- Petaloid staminodes are found in Canna, Hedychium

Parts of Stamens:

- Stamen consists of another & filament
- Anther is fertile & produces pollen grains
- Anther is morphologically equal to microsporangium
- Anther & filament is attached to one another with the help of connective
- In majority of angiosperms (dicots) anthers are dithecous which consists of two pollen sacs
- Dithecous anther is tetralocular
  In members of Malvaceae (Hibiscus, Sida), anthers are monothecous
- Pollen sacs contains microsporangia in which microspores / pollen grains are produced
- In monocots, anther are monothecous & are bilocular
- In Salvia (sage plant) connective is 'U' shaped & another lobes are far separated i.e. they are situated at the tips of 'U'.

Fixation: (attachment of anther to the filament).

1) Basifixed: filaments is attached at the base of anther. Ex: Datura, Brassica
2) Dorsifixed: filament is attached to the anther on the dorsal side.
   Ex: Annona, Passiflora
3) Adnate: filament is attached through out the length of the filament
   Ex: Nelumbium
4) Versatile: tip of the filament is pointed & attached to the anther at a point in such a way that anther can moves in all directions. Ex: Grasses, Delonix, etc

Dehiscence of Anther: The anther wall usually breaks along the stomium to liberate pollen grams

Different modes of dehisce of anther are

1) Longitudinal: anther dehisce vertically Ex: Datura
2) Transverse: anther dehisce transversally/ horizontally Ex: Hibiscus
3) Valvular: anther wall breaks up in the form of values
   Ex: Cassytha, Berberis
4) Porous: (apical): anther wall dehisce at the tips in the form of pores.
   Ex: Cassia, Solanum

Relative lengths of stamens:

1) Didynamous: Androecium consists of 4 stamens out of which 2 stamens
   are short & remaining two are long.
   Ex: Ocimum , Leucas (Labiatae members)

2) Tetradynamous: Androecium consists of 6 stamens out of which 4 stamens
are long & two are short
Ex: Raphnus, Brassica etc
Based on the lengths of stamens with respect other floral parts, they are of
two types ----
a) Inserted stamens: Stamens do not extend beyond the petals i.e. stamens
remains with in corolla tube Ex: Datura, Leaves, Bean
b) Exerted Stamens: Stamens extends beyond the petals i.e stamens protrude out
of corolla tube Ex: Acacia, Croton, Hibiscus

Arrangement of Stamens:

1) Haplostemenous: stamens in one whorl, alternating with petals
Ex: Datura, Catheranthus, Solanum
2) Diplostemenous: stamens in two whorls, outer whorl of stamens alternate with petals Ex: Cassia
3) Obdiplostemenous: stamens in two whorls, outer whorl of stamens are opposite to petals (antipetalous condition) Ex: Citrus

Union of Stamens: In many plants stamens shows Union among themselves & other floral parts

Union of Stamens

Cohension (Connation)

Adhesion (Adnation)

Adelphy Sygenesious Syandrous Epiphyllous Epipetalous Gynandrous

→ Monoadelphous

→ Diadelphous

→Polyadelphous

A) **Cohension of Stamens**: Stamens show union among themselves.
They are of three types ----
1) Adelphy: filaments are united & anthers are free
a) Monoadelphous: all filaments unite to form one bundle
Ex: Hibiscus, Neem, Crotolaria
b) Dialdelphous: filaments unite to form two bundles
Ex: Pea, Bean, Tephrosia, Fumaria
c) Polyadelphous: filaments unite to form many bundles
Ex: Citrus, Bombax
2) Sygensions: anthers are united & filaments are free
Ex: Tridax

3) Synandrous: Stamens unite completely & form single structure.
Ex: Cucurbita, Colocasia, Benicasa (ash guard)

B) **Adhesion of Stamens**: Stamens shows union with other floral organs like sepals, petals or gynoecium

1) Epiphyllous: Stamens unite with perianth Ex: Asparagus
2) Episepalous: Stamens unite with sepals Ex: Proteaceae
3) Epipetalous: Stamens unite with petals Ex: Datura
4) Gynandrous: Stamens unite with gynoecium
It is also known as gynostegium or gynandrium
Ex: Calotropis

Gynoecium: It is the inner most part of flower

- It is female reproductive organ.
- It consists of one or more carpels which are morphologically equal to megasporophyll
- In Angiosperms ovules are inside the ovary
  In Gymnosperms ovules are naked
- Sterile pistil is known as pistillode
- Gynoecium consists of ovary. Style & Stigma
- Ovary is the basal swollen part of gynoecium which contains ovules
- Ovary may be superior, inferior or half superior
- after fertilization ovary develops into fruits & ovules develops into seed
- Above the ovary, long or short style is present which ends with a round, sticky stigma
- During pollination pollen grains are deposited on the stigma

Union of Carpels: when gynoecium consists of more number of carpels, they may show different degree of union such as ----

1) Apocarpous: Carpels are free
Ex: Sedum, Annona, Nelumbo, Rosa, Michelie

- Nelumbo –free carpels are embedded in thalamus
- Michelia: free carpels are present along the length of thalamus
- Sedum: free carpels are present at the base of cup shaped thalamus

2) Sub – apocarpous: carpels shows partial fusion
i) ovaries of carpels are fused & styles & stigmas remain free
Ex: Dianthus Linum
ii) ovaries & styles are fused & stigmas are free Ex: Hibiscus
iii) ovaries & styles are free but stigmas fused Ex: Calotropis
iv) ovaries are free & styles & stigmas are fused
Ex: Catheranthus, Nerium

3) Syncarpous: carpels are united completely & forms a single structure called syngynium Ex: Datura, Dolichos etc

Number of Carpels: depending upon the number of carples, ovary is of different types ----

- Monocarpellary – single carpel Ex: Dolichos, Delonix
- Bicarpellary – 2 carpels Ex: Datura, Brassica
- Tricarpellary – 3 carpels Ex: Allium, Cocos, Cucurbita
- Tetracarpellary – 4 carpels Ex: Gossypium
- Pentacarpellary – 5 carpels Ex: Hibiscus
- Multicarpellary – many carpels Ex: Abutilon, Annona, Citrus

Number of Locules: chambers or compartments of the ovary are known

as locules ---
- ovules are present in the locules
- wall separating the locules is known as septum
- False septum (i.e. replum) may also develop Ex: Datura
- Number of locules are equal to the number of carpels
  Ex: Hibiscus – pentacarpellary, pentalocular
- In some plants number of locules are double the number of carpels
  Ex: Datura – Bicarpellary, tetra locular
- Depending upon the number of locules, ovary is ----

a) Unilocular: ovary with one locule—
Ex: Dolichos – monocarpellary, unilocular
Tridax – bicarpellary, unilocular
Dianthus – multicarpellary, unilocular

b) Bilocular: ovary with two locules Ex: Solanum

c) Trilocular: 3 locules Ex: Allium

d) Penta locular: 5 locules Ex: Hibiscus

e) Multilocular: many locules Ex: Citrus, Abutilon

Placentation:
- arrangement of ovules on the placenta is known as placenlation
- placenta is a special tissue which may be located along ventral suture
- Different types of placentation are ----

a) Marginal placentation: ovules are arranged on the margin of ventral suture
- Seen in members of Legumenosae

b) Parietal placentation: ovules are arranged on the placenta in two rows along both the sutures Ex: Members of Brassicaceae & Cucurbitaceae

c) Axile: Ovules are arranged on the central axis of multicarpellary ovary.
Ex: Datura, Solanum, Cycopersicon esculentum etc

d) Free central placement: ovules are developed around the central axis of unilocular ovary Ex: Dianthus, Primula

d) Basal placentation: ovules are attached to the placenta present at the base of ovary Ex: Tridax, Ocimum, Leucas, Hannus etc

f) Apical or Pendulous placentation: placenta is present at the apex roof of the ovary & ovules hangs down from the placenta Ex: Nelumbium

g) Superficial placentation: (laminar): ovules are distrubuted throughout the placenta. Ex: Nymphaea

Style: Stalk like structure present above the ovary.
- It may be long or short or may be absent
- In Naravelia, Clemalis, Digitalis style is persistant
- In Canna, Iris style is petaloid
- In Umbellifera style is swollen & forms Stylopodium

Types of Styles:

a) Terminal: style arises from base of ovary
Ex: Datura, Hibiscus, Solanum

b) Lateral: style arises from the lateral side of ovary Ex: Mango

c) Gynobasic: style arise from the base of ovary Ex: Ocimum

Stigma:

- terminal part of gynoecium which receives the pollen grains are known as stigma
- it secretes sugary substance which helps in germination of pollen grains
  Stigma may be of different types----
  i) Capilate / Round stigma Ex: Hibiscus, Citrus
  ii) Feathery or Brush like Ex: Grasses
  iii) Bifid or forked Ex: Tridax
  iv) Dumbell like Ex: Catheranthus
  v) Wheel like Ex: Papaver
  vi) Sensitive Ex: Mimulus, Martynice
  vii) Funnel shaped Ex: Crocus
- Plants which gives flower only one in their life time are called as monocarpic
- Flowers of Caesalpina pulchevina are called "Paecock flowers"
- Flowers of Calceolaria are called "Common slipper flowers"
- Period of opening of flowers is known as anthesis
- Gradual transition of sepals to carpels is seen in Nymphaea

ROOT & ROOT MODIFICATION

MULTIPLE CHOICE QUESTIONS

Exercise – 1

1) Plants differs from animals by having
   A) Autrophic nature
   B) Continuous growth throughout their life
   C) Cellulosic cell wall
   D) Fixation to the substratum
   1) A, B only 2) A, B, C, D 3) A, C only 4) A, C, D only
2) Various characters of plant like colour, shape, flowers and fruit etc. are determined and governed by
   1) Genes 2) Ribosomes 3) Fatty acids 4) Organic acids
3) Study the following and identify the correct match

Group	Life span
A) Ephermerals	I) Many years
B) Annuals	II) Two years
C) Biennials	III) One year
D) Perennials	IV) 6 – 8 weeks

   A B C D   A B C D
   1) IV III I II   2) III IV II I
   3) IV III II I   4) III IV I II
4) Fastest growing plant is
   1) Euphorbia 2) Cycas 3) Areca 4) Bamboo
5) Spermatophytes start their life activities with the germination of their
   1) Microspores 2) Mega spores 3) Seeds 4) Gametes
6) Lateral roots develop in
   1) Acropetal succession 2) Basipetal succession
   3) Obliquely 4) 1 & 3
7) Corolla in mustard (Bassica nigrum) is

1) Cruciform 2) Rosaceous 3) Caryophyllaceous 4) Ligulate

8) Inflorescence in Brassica is
1) Simple spike 2) Panicle 3) Simple raceme 4) Simple corymb

9) Invisible part of the shoot system is
1) Axis2) Axil 3) Bract4) Peduncle

10) The condensed tip of the pedicle is called
1) Thalamus 2) Torus 3) Peduncle 4) 1 or 2

11) Common character in both stem and root is
1) Nodes 2) Buds 3) Root hairs 4) Apical growth

12) Arrange the following zones of root from apex to base
A) Growth & Elongation B) Maturation
C) Root apex D) Piliferous
1) B, D, A, C 2) B, D, C, A 3) C, A, B, D 4) C, A, D, B

13) Calyptra or root cap arises from
1) Calyptrogen 2) Plerome 3) Periblem 4) Tunica

14) Root pockets are found in
1) Pistia 2) Eichhornia 3) Lemna 4) All the above

15) Root hairs are
1) Uniseriate 2) Multiseriate 3) Unicellular 4) Multicellular

16) Assertion: Root hairs are not trichomes
Reason: Root hairs is the extension of epidermal cell but not outgrowth
1) Both A and R are true and R is the correct explanation of A
2) Both A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

17) Root hairs are long lived in
1) Xerophytes 2) Mesophytes 3) Hydrophytes 4) All the above

18) Root hairs are absent in
1) Parasites 2) Epiphytes 3) Mycorrhiza 4) All

19) Root less plant is
1) Wolffia 2) Salvinia 3) Ceratophyllum 4) All the above

20) Plants exclusively survives with roots is
1) Tinospora 2) Taeniophyllum 3) Trapa 4) Salvinia

21) Tap root system and adventitious root system differs from each other with respect to
1) Function 2) Origin 3) Chlorenchyma 4) Absorption of water

22) Adventitious root system is commonly found in the members of
A) Pteridophytes B) Gymnosperms C) Dicots D) Monocots
1) D only 2) B, D 3) C, D 4) A, D

23) Identify the plants which store their reserve food in tap roots
A) Daucus B) Ipomoea C) Ruellia D) Raphanus E) Beta
1) A, D only 2) A, D, E 3) C, D, E 4) A, B, D, E

24) A monocot with fasciculated tuberous roots is
1) Ruellia 2) Asparagus 3) Ipomoea 4) All

25) Reserve food in Dahlia roots is
1) Sucrose 2) Stachyose 3) Starch 4) Inulin

26) Fasciculated tuberous roots which store both food & water in the form of mucilage are
1) Asparagus 2) Beta 3) Raphanus 4) Ipomoea

27) Root crops are
1) Ephemerals 2) Annuals 3) Biennials 4) Perennials

28) Identify the mismatch

Tuberous Root Shape
1) Carrot – Conical
2) Beet root – Napiform
3) Radish – Spindle
4) Sweet Potato – Napiform

29) Radical leaves are found in
1) Radish 2) Beet root 3) Carrot 4) All

30) Single adventitious root develops into tuberous root in
1) Ipomoea batatus 2) Radish 3) Ruellia 4) Asparagus

31) Identify the incorrect statement regarding root crops
1) They show vegetative growth in the first year
2) Active photosynthesis occurs in the first year
3) They utilise the stored food during second year for the production of fruits, flowers and seeds
4) They are harvested at the end of second year

32) Root crop which grows for sucrose production is
1) Sugarcane 2) Radish 3) Beet root 4) 1 & 3

33) Epiphytes usually grow in
1) Scrub jungles 2) Riparian forests
3) Evergreen forests 4) Dry deciduous forests

34) Epiphytes mostly belong to
1) Orchidaceae 2) Poaceae
3) Podostemonaceae 4) Trapaceae

35) Epiphytes grow on other trees, to get
1) Shelter 2) Sunlight 3) Food 4) 1 & 2

36) Fixing roots in Epiphytes are
1) Pull roots 2) Velamen roots 3) Clinging roots 4) Spongy roots

37) Velamen roots are useful for
1) Fixation
2) Absorption of minerals
3) Mechanical support
4) Absorption of moisture from atmosphere

38) Multiple epidermis is found in the roots of
1) Vanda 2) Ficus 3) Nerium 4) 1 & 3

39) Velamen tissue is
A) Dead B) Hygroscopic C) Epidermal tissue
1) A only 2) A, B only 3) B, C only 4) A, B, C

40) Hygroscopic roots are found in
1) Epiphytes 2) Halophytes 3) Mangroves 4) Hydrophytes

Exercise – 2

1) Breathing roots are traced in (cmpt 1993)
1) Rhizophora 2) Epiphytes 3) Avicennia 4) Both 1 & 3

2) The fibrous root system is better adapted than the tap root functionally to perform (BHU 1993)
1) Food storage 2) Attachment to soil
3) Water and mineral absorption 4) Transport of water and minerals

3) The plant, which bears clinging roots, is(cbse pmt 1993)
1) Podostemon 2) Screw pine 3) Orchid 4) Trapa

4) Stilt roots are characteristic of (Bihar PMT 1993)
1) Pandanus 2) Mangifera 3) Ficus4) Mirabilis
5) Tap roots are commonly found in (cbse pmt 1993)
1) Gymnosperms 2) Dicots 3) Monocots 4) Both 1 & 2
6) Velamen is the modified epidermis for absorbing moisture from (Bihar PMT 1994)
1) Bark 2) Air 3) Leaves 4) Roots
7) Trichosanthes is a beautiful example of (Manipal PMT 1994)
1) Assimilatory roots 2) Reproductive roots
3) Mycorrhizae 4) Respiratory roots
8) Which one is not an edible root? (CPMT 1994)
1) Carrot 2) Turnip 3) Potato 4) Sugarbeet
9) Parasitic plants obtained their nutrition through (cmpt 1995)
1) Primary roots 2) Adventitious roots 3) Pores 4) Haustoria
10) Nodulated roots are characteristic of family (RPMT 1995)
1) Solanaceae 2) Leguminosae 3) Malvaceae 4) None above
11) The thick roots that hang down from a banyan tree are called (BHU 1995)
1) Stilt roots 2) Prop roots 3) Pneumatophores 4) Butteress roots
12) Xerophytes have long roots (afmc 1995)
1) To give mechanical support 2) Due to light
3) To draw water from deep water beds 4) Due to temperature
13) Pneumatophores are present in plants growing in (Haryana PMT 1995)
1) Fresh water 2) Salty marshes 3) Desert 4) Hilly places
14) The rhizome differs from root in respect of (AFMC 1995)
1) Its thick 2) Thin roots
3) Scale leaves at nodes & buds in axil 4) Green colour
15) Ginger and sweet potato are (Haryana PMT 1995)
1) Homologus 2) Stem & roots respectively
3) Analogous 4) Both 2 & 3
16) Plants like Rhizophora and Avicennia grow on the sea shores under saline conditions. For this, they have special roots for respiration which are called (KCET 1995)
1) Prop roots 2) Climbing roots 3) Pneumatophores 4) Floating roots
17) The aerial absorptive roots are found in (JEE, Orissa 1995)
1) Mesophytes 2) Epiphytes 3) Hydrophytes 4) Xerophytes
18) Which of the following produce stilt roots? (BHU 1996)
1) Acacia 2) Screw pine 3) Catotropis 4) Banyan
19) Haustorial roots can be traced in (BHU 1996)
1) Cuscuta 2) Banyan 3) Tinospora 4) All above
20) Pnematophores are used in (BHU 1996)
1) Photosynthesis 2) Respiration 3) Protein synthesis 4) Secretion of salt
21) Fusiform roots are found in (BHU 1996)
1) Colocasia 2) Daucus 3) Raphanus 4) All above
22) Adventitious roots develop from (AFMC 1994, CET Chd 1997)
1) Radical 2) Flower 3) Embryo 4) Any part of plant body except radical
23) Roots can be used for vegetative propagation of (JIMPER 1997)
1) Potato 2) Chrysanthermum 3) Mesophytes 4) Ginger
24) Root cap is absent in (BHU 1997)
1) Hydrophytes 2) Xerophytes 3) Mesophytes 4) Lithophytes
25) Mycorrhiza serves the function of (CPMT 1998)
1) Modified leaf 2) Modified shoot 3) Root hair 4) All above
26) Characteristic feature of hydrophytes is (RPMT 1998)

1) Stem with well developed sceleranchyma 2) Poorly developed roots
3) Well developed xylem 4) Well developed roots

27) The conical root of carrot is a (KCET 1998)
1) Haustrial root 2) Adventitious root 3) Tap root 4) Fibrous root

28) A submerged rooted hydrophyte is (CPMT 1998)
1) Trapa 2) Vallisneria 3) Utricularia 4) None of these

29) Clinging roots are characteristic of (CBSE PMT, 1999)
1) Orchids mascula 2) Trapa 3) Screwpine 4) Podostemon

30) Exceptional roots of Cuscuta are (JIMPER, 1999)
1) Haustoria 2) Coralloid 3) Mycorhizal 4) All above

Keys

Ex- 1

1) 2	2) 1	3) 3	4) 4	5) 3	6) 4	7) 1	8) 3	9) 2	10) 4
11) 4	12) 4	13) 1	14) 4	15) 3	16) 1	17) 1	18) 4	19) 4	20) 2
21) 2	22) 4	23) 2	24) 2	25) 4	26) 1	27) 3	28) 4	29) 4	30) 1
31) 4	32) 3	33) 3	34) 1	35) 4	36) 3	37) 4	38) 1	39) 4	40) 1

Ex –2

1) 4	2) 3	3) 3	4) 1	5) 4	6) 2	7) 2	8) 3
9) 4	10) 2	11) 2	1) 3	13) 2	14) 3	15) 4	16) 3
17) 2	18) 2	19) 1	20) 2	21) 3	22) 4	23) 3	24) 1
25) 3	26) 2	27) 3	28) 2	29) 1	30) 1		

STEM & STEM MODIFICATION
MULTIPLE CHOICE

Exercise – 1

1) Axis of the shoot system is
1) Stem 2) Radicle 3) Tigellum 4) Peduncle

2) First bud of the plant is
1) Radicle 2) Plumule 3) Cortyledon 4) Endosperm

3) Branches develop on stem
1) Horizontally 2) Vertically downwards 3) Obliquely 4) 1 or 3

4) Study the following and identify the correct match

Name	Shape of Stem
A) Cyperus	I) Ridged
B) Cucurbita	II) Triangular
C) Hibiscus	III) Quadrangular
D) Leucas	IV) Cylindrical

A B C D
1) II I III IV
3) II I IV III

A B C D
2) I II IV III
4) I III IV II

5) Linear growth of stem is due to the activity of
1) Axillary bud 2) Epiphyllous bud 3) Radicle bud 4) Terminal bud

6) Stem is absent in this plant
1) Tinospora 2) Taeniophyllum 3) Trapa 4) Cuscuta

7) Identify the sensitive structures of stem
A) Tendrils B) Hooks C) Thorns D) Spines
1) A, B 2) A only 3) ABC 4) ABCD
8) Stem tendrils are found in
A) Cissus B) Smilax C) Vanilla D) Passiflora E) Vitis
1) ABDE 2) AD only 3) ADE 4) ABCDE
9) Tendril is opposite to leaf in
1) Artabotrys 2) Cissus 3) Passiflora 4) Glorisa
10) Weak stemmed plants which are climbing the support with the help of books and thorns are called
1) Lianes 2) Twiners 3) Stragglers 4) Runners
11) Thorns bear leaves in
A) Punica B) Duranta C) Bougainvillae D) Carissa
1) A, B 2) B only 3) A only 4) ABCD
12) Identify the plants which climb with thorns
A) Duranta B) Artabotrys C) Bougainvillae D) Carrisa
1) A, B, C 2) A only 3) B, C 4) A, C
13) Axillary buds are modified into hooks in
1) Artabotrys 2) Duranta 3) Hugonia 4) Punica
14) Peduncle is modified into hook in
1) Artabotrys 2) Artocarpus 3) Aristolochia 4) Asparagus
15) 'Areole' is found in
1) Asparagus 2) Ruscus 3) Opuntia 4) Cocoloba
16) Circlet of scale leaves are found in
1) Casuarina 2) Ruscus 3) Asparagus 4) Opuntia
17) Identify the incorrect statement regarding Opuntia
1) Leaf is modified into scale leaf
2) Photosynthesis stem grows indefinitely
3) Shape of phylloclade is flattened
4) Flowers arise on phylloclades
18) Assertion: In Bulbophyllum the tuberous stem is called 'pseudo bulb'.
Reason: In Bulbophyllum generally one internode of the stem stores food and water
1) Both A and R are true and R is the correct explanation of A
2) Both A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true
19) Stem modification in Knol Knol is
1) Stem tuber 2) Pseudo bulb 3) Tuberous stem 4) Bulb
20) Entire aerial stem becomes tuberous in
1) Potato 2) Colocasia 3) Bulbophyllum 4) Knol Knol
21) Bulbils are developed in axils of bracts in
A) Agave B) Globba C) Oxalis D) Dioscorea
1) A, D, C 2) A, B 3) D only 4) A only
22) Stem and root both are modified in
A) Oxalis B) Asparagus C) Amorphophallus D) Eicchhornia
1) A only 2) AB only 3) BCD only 4) ABCDE
23) Leaf axil contains bulbil in
1) Dioscorea 2) Ananas 3) Globba 4) Oxalis
24) Prostrate stems rooted at every node are called
1) Suckers 2) Stolons 3) Runners 4) Offsets

25) Principal behind the 'Layering' technique is
1) Stolons 2) Runners 3) Offsets 4) Suckers
26) Sub aerial stem modification which contain many nodes and internodes is
A) Runner B) Stolon C) Sucker D) Offset
1) A only 2) B, C only 3) C only 4) Except 'D'
27) Condensed stem is found in this plant
1) Rosa 2) Pistia 3) Lippia 4) Mentha
28) Both Sub aerial stem modification and root modification are found in
1) Oxalis 2) Pistia 3) Eichhornia 4) All
29) Both underground and sub aerial stem modifications are found in
1) Musa 2) Agave 3) Oxalis 4) All
30) Both aerial and sub aerial stem modification are found in
A) Agave B) Oxalis C) Dioscorea D) Casuarina
1) A only 2) A, B 3) B, C 4) A B C D
31) Number of internodes found in one offset is
1) 1 2) 2 3) 3 4) Many
32) Terrestrial plant with offsets is
1) Oxalis 2) Jasminum 3) Agave 4) Musa
33) Multi purpose stem modifications are further divided on the basis of
1) Growth pattern 2) Parts which store food material
3) Colour 4) 1 & 2
34) Assertion: Rhizome grows horizontally in the soil
Reason: Axillary buds grow vertically in rhizome
1) Both A and R are true and R is the correct explanation of A
2) Both A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true
35) Underground stem which does not produce roots is
1) Bulb 2) Stem tuber 3) Rhizome 4) Corm

Exercise – 2

1) The food stored in the bulb of an onion, is in
1) Stem 2) Inflorescence 3) Leaf base 4) Fleshy root
2) Passiflora is the example of
1) Stem-tendril 2) Phyllocade 3) Thorn 4) Cladode
3) The main difference between biennials and perennials plants is that the perennials
1) Are tree species
2) Do not die after seasonal production of fruits
3) Invariably show asexual reproductive structure
4) Always have underground perennating structure
4) Muehlenbeckia is a good example of
1) Phyllode 2) Phyllocade 3) Winged fruit 4) Parachute mechanism
5) In which of the following does the stem perform the function of storage and perennation?
1) Groundnut 2) Ginger 3) Wheat 4) Radish
6) A plant that grows inside a plant of another species symbiotically is called
1) A parasite 2) A saprophyte 3) A semiparasite 4) An endophyte
7) Colocasia vegetatively reproduce by
1) Rhizome 2) Corm 3) Runner 4) Bulbs

8) Zingiber vegetatively reproduce by
   1) Bud 2) Stem 3) Tuber 4) Bulbs
9) Bougainvillea is the modified thorn formed from
   1) Stem 2) Leaf 3) Lateral roots 4) Root
10) It is justified that potato is the underground stem because it
   1) Possesses axillary buds 2) Lacks chlorophyll
   3) Doesnot bear roots 4) Contains reserve food
11) Potato tuber is modified
   1) Stem 2) Root 3) Bud scale 4) Leaf petiole
12) Cladodes belong to
   1) Mesophytes 2) Hydrophytes 3) Xerophytes 4) Parasites
13) The following are characteristic of monocots
   1) Fibrous root system, parallel venation of leaves, trimerous floral parts and two cotyledons
   2) Fibrous root system, parallel venation of leaves, trimerous floral parts and one cotyledon
   3) Fibrous root system, leaves with reticulate venation, trimerous floral parts & one cotyledon
   4) Tap root system, parallel venation of leaves, trimerous floral parts and one cotyledon
14) When the stem is modified into a green flattened structure, it is called
   1) Bulbil 2) Tendril 3) Phyllode 4) Phyllocade
15) Corm is an
   1) Underground vertical leaf 2) Underground swollen stem
   3) Underground horizontal root 4) Underground horizontal leaf
16) In Opuntia, the spines are modifications of
   1) Stem 2) Leaves 3) Roots 4) All above
17) Most reduced stem can be traced in
   1) Stem corm 2) Rhizome 3) Stem tuber 4) Bulb
18) Floral bud tendril can be traced in
   1) Circus 2) Smilax 3) Cucurbita 4) Antigonon
19) Thorns are modified stem because. They
   1) Arise from the buds in the axil of leaves
   2) Arise from branches
   3) Arise from stem
   4) Are defensive organs for grazing
20) Which of the following is the largest and edible bud?
   1) Onion 2) Agave 3) Cabbage 4) Cauliflower
21) The plants in desert inorder to tolerate water stress, have
   1) No stomata 2) Long root system to reach the water level
   3) Stipular spines 4) Stems which are converted into leaf type
22) The smallest gymnosperm is
   1) Ephedra 2) Zamia 3) Cycas 4) None of the above
23) Acacia arabica is a
   1) Mesophyte 2) Xerophyte 3) Hydrophyte 4) Halophyte
24) Dichotomous branching is found in
   1) Funaria 2) Fern 3) Marchantia 4) Conifers
25) Water plants usually have well developed
   1) Root system 2) Vascular system 3) Stem 4) Aerenchyma
26) In stem, which of the following give rise to adventitious branches?

1) Epidermis 2) Cortex 3) Pericycle 4) Endodermis

27) A ginger plant has an underground stem called
 1) Rhizome 2) Bulb 3) Tuber 4) Corm

28) A phylloclade is a modified
 1) Root 2) Bulb 3) Stem 4) None of these

29) A stem with distinct solid nodes and hollow internodes is
 1) Sobole 2) Culm 3) Scape 4) Intercalary stem

30) One of the following has stem tendrils
 1) Clematis 2) Vitis 3) Smilax 4) Gloriosa

Keys

Ex – 1

1)1	2)2	3)4	4)3	5)4	6)2	7)1	8)3	9)2	10)3	11)1
12)4	13)3	14)1	15)3	16)1	17)1	18)2	19)3	20)4	21)2	22)4
23)1	24)3	25)1	26)4	27)2	28)4	29)1	30)2	31)1	32)3	33)4
34)3	35)2									

Ex –2

1)3	2)1	3)2	4)2	5)2	6)4	7)2	8)4
9)1	10)1	11)1	12)3	13)2	14)4	15)2	16)2
17)4	18)4	19)1	20)3	21)2	22)2	23)2	24)3
25)4	26)2	27)1	28)3	29)2	30)2		

LEAF & LEAF MODIFICATION
MULTIPLE CHOICE

Exercise – 1

1) Development and origin of leaf respectively is
 1) Endogenous, node 2) Exogenous, node
 3) Exogenous, internode 4) Endogenous, internode

2) Leaves are produced in
 1) Basipetal succession 2) Centripetal manner
 3) Acropetal succession 4) Centrifugal manner

3) The organs of limited growth are
 1) tap – root 2) main stem is Polyalthia
 3) Lateral branches in Tamarindus 4) Leaves

4) Leaves act as indicators in various environmental conditions due to its
 1) Shape 2) Colour 3) Large surface area 4) Large stomatal frequency

5) Leaves which grow on the stem are called
 1) cauline 2) ramal 3) radicle 4) radicle 4) 1 & 2

6) Cauline leaves are found in
 1) Cocos 2) Cycas 3) Borassus 4) All

7) Leaves which are developed from reduced stem are called
 1) cauline 2) ramal 3) radical 4) 2 & 3

8) Leaves which are developed from reduced stem are called
1) Radical 2) Cauline 3) Ramal 4) 1& 3
9) Radical leaves are found in
1) Cocos 2) Allium 3) Hibiscus 4) Borassus
10) The leaves fall off immediately after their development are called
1) deciduous 2) caducous 3) perennial 4) permanent
11) Caducous leaves are found in
1) Cocos 2) Opuntia 3) Michelia 4) Allium
12) The leaves with a life span of one season to one year are called
1) Deciduous 2) Caducous 3) Perennial 4) Persistent
13) Leaves are absent in
1) Parasites 2) Saprophytes 3) Symbionts 4) Autotrophs
14) Angiospermic saprophytic plant is
1) Monotropa 2) Cuscuta 3) Glomus 4) Nepenthes
15) Hydrophyte with largest peltate leaves are found in
1) Rafflesia 2) Victoria regia 3) Nelumbo 4) Raffia tidigera
16) Terrestrial palm with longest leaves (22m) are present in
1) Victoria regia 2) Nymphea 3) Raffia taedigera 4) 1 & 3
17) The long sheath like leaf base encircles a part of stem is called
1) Sheathing leaf base 2) Pulvinous leaf base
3) Storage leaf base 4) Cup – like base
18) Sheathing leaf base protects
1) Many dicots 2) Many monocots 3) Many grasses 4) 2 & 3
19) Sheathing leaf base protects
1) Apical meristem 2) Intercalary meristem
3) Lateral meristem 4) Fasicular cambium
20) Aerial pseudo stem in Musa is formed by
1) Sheathing leaf bases 2) Stipules
3) Lamina 4) Pulvinous leaf base
21) Pulvinous leaf base is found in
1) Monocots 2) Legumes 3) Cereals 4) Malvaceae
22) Pulvinous leaf base causes
1) Nastic movements 2) Tactic movements
3) Tropic movements 4) All
23) Leaf – lets show nastic movement due to pulvinous leaf base in
1) Mimulus 2) Mimosa 3) Martynia 4) Morus
24) Concentric arrangement of fleshy leaf bases forms a
1) pseudo bulb 2) naked bulb 3) tunicated bulb 4) scaly bulb
25) Persistent rhomboidal leaf base is present in
1) Allium 2) Cycas 3) Cyperus 4) Cicer
26) The small green lateral appendages present on either side of the leaf base are called
1) Bracts 2) Stipels 3) Stipules 4) Bracteoles
27) Stipules are prominent and very rare respectively in
1) Monocots, dicots 2) Dicots, monocots
3) Dicots, dicots 4) Monocots, Pteridophytes
28) Stipules give protection to
1) Axillary bud in fully developed stage
2) Terminal bud is developing stage
3) Axillary bud is developing stage
4) Both axillary and terminal bud is developing stage

29) Deciduous stipules are found in
1) Michelia 2) Rosa 3) Pisum 4) Acacia
30) Persistent foliose stipules are present in
1) Pisum 2) Lathyrus 3) Rosa 4) 1 & 2
31) Persistent non-foliose stipules are found in
1) Acacia 2) Rosa 3) Smilax 4) All
32) Stipulate leaves are found in
1) Malvaceae 2) Asteraceae 3) Fabaceae 4) 1 & 3
33) Monocot with stipulate leaf is seen in
1) Solanum 2) Aloe 3) Smilax 4) Gloriosa
34) Dicots with ex-stipulate leaves are noticed in
1) Asteraceae 2) Solanaceae 3) Liliaceae 4) 1 & 2
35) Persistent, branched stipules is seen in
1) Ipomea batatus 2) Ipomea quamoclit
3) Smilax zeylanica 4) Pisum sativum
36) Number of free-lateral stipules in Hibiscus per each leaf is
1) 1 2) 3 3) 2 4) Many
37) Tendrillar climbing stipules are found in
1) Spanish dagger 2) Sarasaparilla
3) Aswagandha 4) Sweet pea
38) Spinous protective stipules are seen in
1) Acacia arabica 2) Parkinsonia
3) Zizyphus 4) All
39) Dimorphic spinous stipules is observed in
1) Parkinsonia 2) Zizyphus 3) Acacia melanoxylon 4) Polygonum
40) Stipules are only photosynthesis structures in
1) Pisum 2) Parkinsonia 3) Lathyrus 4) 1 & 3
41) Stipulate and stipellate leaves are seen in
1) Pisum 2) Dolichos 3) Hibiscus 4) Gloriosa
42) Leaves are sessile in
1) Nicotiana 2) Aster3) Gloriosa 4) All
43) Long, flexible, gelatinous petioles are found in
1) Free – floating plants 2) Submerged plants
3) Rooted with floating leaves 4) Amphibious plants
44) Sensitive, tendrillar, petioles help in climbing in
1) Clematis 2) Clitoria 3) Cicer4) Colchicum
45) Winged petiole is found in
1) Citrus, Nepenthes, Dionaea 2) Citrus, Nepenthes, Drosera
3) Smilax, Lathyrus, Pisum 4) All
46) Petioles are spongy in
1) Eichhornia, Pistia 2) Trapa, Eichhornia
3) Trapa, Pistia 4) Jussiea, Salvinia
47) Leaf- like photosynthesis petiole is called
1) Phyllode 2) Phylloclade 3) Cladode 4) All
48) The important functions of the leaf are performed by
1) Petiole 2) Lamina 3) Stipules 4) Leaf base
49) Multicostate reticulate convergent venation is present in
1) Oryza, Cinnamomn 2) Zizyphus, Borassus
3) Zizyphus, Cinnamomm 4) Oryza, Borassus
50) Name cryptogam and phanerogam exhibit habitual heterophylly respectively

1) Artocarpus, Selaginella 2) Selaginella, Dolichos
3) Selaginella, Acacia 4) Selaginella, Artocarpus

51) Tripinnate, trifoliate compound leaves are present respectively in
1) Citrus, Dolichos 2) Millingtonia, Dolichos
3) Moringa, Dolichos 4) 2 & 3

52) Palmately lobed simple leaf with palmately reticulate venation is found in
1) Hibiscus 2) Gossypium 3) Borassus 4) Oryza

53) Simple leaves are polymorphic is
1) Ananas 2) Artabotrys 3) Annona 4) Artocarpus

54) Opposite leaves of all the nodes are found one above the other in
1) Calotropis 2) Quisqualis 3) Quercus 4) Leucas

55) Stipules and lamina is lobed in
1) Ipomoea batatus 2) Pisum sativum
3) Ipomoea quamoclit 4) Lathyrus sativus

56) Number of new plants developed from a healthy leaf of Begonia is
1) Many 2) Zero 3) One 4) Three

57) In Calotropis
1) Opposite, leaves of all nodes lie one above the other
2) Opposite, leaves are arranged in two vertical leaves
3) Opposite leaves of alternate nodes lie right angle to each other
4) Opposite leaves of alternate nodes lie one above the other

58) The modified petiole performs both physiological & mechanical function in
1) Acacia melanoxylon 2) Nepenthes
3) Clematis 4) Quisqualis

59) Leaf tendrils and unipinnately compound with imparipinnate leaf is present in
1) Lathyrus 2) Passiflora 3) Pisum 4) Smilax

60) Winged photosynthesis petiole with a simple leaf – like compound leaf is observed in
1) Clematis 2) Citrus 3) Zornea 4) Dolichos

61) Petioles are unequal with axillary catkins are noticed in
1) Carica 2) Gynandropsis 3) Acalypha 4) Casuarina

62) Spines are dimorphic in
1) Citrus 2) Zizyphus 3) Acacia arabia 4) 1 & 2

63) Kind of venation in medicinal plant with bulbils which develop from axillary vegetative buds
1) Pinnate reticulate 2) Pinnate parallel
3) Palmate reticulate 4) Palmate parallel

64) Exogenously developed, limited growth, lateral expanded appendages with vascular tissues are first found in
1) First embryophytes 2) First spermatophytes
3) Last atracheophytes 4) First tracheophytes

65) Type of venation found in a plant showing vegetative bulbils in the axile of leaf
1) Palmate reticulate divergent 2) Palmate reticulate convergent
3) Palmate parallel convergent 4) Palmate parallel divergent

66) Vernation is
1) Arrangement of veins on the lamina 2) Arrangement of leaves on the stem
3) Arrangement of leaves in bud 4) 1 & 2

67) Identify the plants showing alternate, opposite and whorled phyllotaxy respectively
1) Hibiscus, Calotrpis are Nerium 2) Hibiscus, Quisqualis, and Nerium

3) Nerium, Hydrilla, Launea 4) 1 & 2

68) Name the shrub that reproduce vegetatively and also contain persistent stipules
1) Rosa 2) Pisum 3) Michelia 4) Zizyphus

69) Dimorphic petiole and dimorphic leaf-lets are found respectively in
1) Pisum, Nepenthes 2) Nepenthes, Zizyphus
3) Nepenthes, Pisum 4) Nepenthes, Lathyrus

70) Protective structures at each node in Parkinsonia are modified
1) Stipules 2) Secondary rachii 3) Primary rachis 4) 1 & 3

Exercise – 2

1) A simple leaf is present in
1) Peepal 2) Mimosa 3) Neem 4) All the above

2) Bipinnate leaves are characteristic of
1) Cruciferae 2) Solanaceae 3) Papilionoideae 4) Mimosoideae

3) A dicotyledenous plant showing parallel venation is
1) Dioscorea 2) Smilax 3) Calophyllum 4) Hibiscus

4) Parkinsonia shows one of the following modifications
1) Phylloclade 2) Cladode 3) Phyllode 4) Leaf pitcher

5) Onion stores food in
1) Underground stem 2) Fleshy scales
3) Root 4) Shoot

6) Phyllode is a modification of
1) Petiole 2) Stem 3) Inflorescence 4) Root

7) Which one is not a modification of stem
1) Pitcher of Nepenthes 2) Corm of Colocasia
3) Rhizome of Ginger 4) Tuber of Potato

8) A monocot can be distinguished from a dicot by
1) Phyllotaxy 2) Aestivation 3) Venation 4) Vernation

9) A unipinnate compound leaf can be differentiated from a branch having simple leaves by
1) Presence of terminal bud in compound leaf
2) Absence of veins in the leaflets
3) Presence of buds in the axils of leaflets
4) Presence of buds in the axils of leaves

10) The leaf of Bryophyllum grows many tiny plants complete with roots in the margins. This is an example of
1) Sexual reproduction 2) Vegetative reproduction
3) Fission 4) Hermaphroditism

11) Adnate stipules occur in
1) China Rose 2) Gardenia 3) Rose 4) Cotton

12) A portion of leaf blade can regenerate the whole plant in
1) Dioscorea 2) Bryophyllum 3) Pineapple 4) Peepal

13) Leaves fall off from branches in winter due to
1) Formation of abscission layer 2) Shortening of day length
3) Fall in temperature 4) All the above

14) Tendrillar stipules occur in
1) Dolichos lablab 2) Acacia
3) Smilax 4) Mango

15) Leaf scar in the area of leaf fall protects the plant from

1) Heat 2) Evaportion 3) Air 4) Transpiration

16) Petiole is modified into green leafy structure called
1) Phyllode 2) Phylloclade 3) Cladode 4) Foliaceous petiole

17) A leaf without petiole is
1) Subpetiolate 2) Sessile 3) Subsessile 4) All the above

18) A plant with parallel venation is
1) Castor 2) Grass 3) Colocasia 4) Mustard

19) Main function of leaf is
1) Manufacture of food 2) Nerve impulse conduction
3) Increasing grandeur 4) Exchange of gases

20) Arrangement of leaves on a stem branch is
1) Venation 2) Vernation 3) Ptyxis 4) Phyllotaxy

21) Bud scales of Ficus are modified
1) Leaves 2) Stipules 3) Stem 4) Prickles

22) Occurence of more than one type of leaves on the same plant is
1) Heterophylly 2) Phyllotaxy 3) Venation 4) Vernation

23) Spiny leaf margins are found in
1) Opuntia 2) Papaver 3) Argemone 4) Polythia

24) A modification of leaf is
1) Phyllode 2) Phylloclade 3) Cladode 4) Corm

25) Ochrete stipules occur in the family
1) Cruciferae 2) Solanaceae 3) Compositae 4) Polygonaceae

26) Free lateral stipules occur in
1) Cruciferae 2) Solanaceae 3) Compositae 4) Polygonaceae

27) Bignonia is
1) Twiner 2) Hook climber 3) Thorn climber 4) Tendril climber

28) Swollen petiole of Eichornia has
1) Collenchyma 2) Chlorenchyma 3) Parenchym 4) Aerenchyma

29) Free lateral stipules occur in
1) Mango/ Mangifera 2) Maize/ Zea
3) Rice/ Oryza 4) China Rose / Hibiscus

30) Storage leaves occur in
1) Allium 2) Zizyphus 3) Triticum 4) Trapa

31) In Gloriosa (Glory Lily) the tendril is formed from
1) Stipule 2) Leaf apex 3) Axillary bud 4) Leaf

32) Stipules are modified into tendrils in
1) Asphodelus 2) Artabotys 3) Smilax 4) Gloriosa

33) Phyllotaxy is the arrangement of
1) Leaflets 2) Leaves 3) Stipules 4) Branches

34) In Acacia species, the first few leaves are pinnately compound. Then there are leaves with flattened petiole and fewer pinnae. The leaves of adult plant has parallel veined flattened petiole and no pinnae. It shows that
1) Leaves of adult plant are reduced to phyllodes while those of the seeding are unreduced
2) The parallel – veined green structures of the adult plant are phylloclades
3) The plant shows developmental heterophylly, compound in seeding and simple in adult plant
4) The leaves of adult plant are unreduced while they are reduced in the seeding stage

35) Finely dissected leaves occur in

1) Free floating plants 2) Rooted floating leaved plants
3) Submerged plants 4) Emerged plants

Keys
Ex – 1

1) 2	2)3	3) 4	4) 3	5)1	6)4	7)2	8)1	9)2	10)2
11)2	12)1	13)2	14)1	15)2	16)3	17)1	18)4	19)2	20)1
21)2	22)1	23)2	24)3	25)2	26)3	27)2	28)3	29)1	30)4
31)4	32)4	33)3	34)4	35)2	36)3	37)2	38)4	39)2	40)3
41)2	42)4	43)3	44)1	45)1	46)2	47)1	48)2	49)3	50)4
51)4	52)2	53)4	54)2	55)3	56)2	57)4	58)2	59)3	60)2
61)3	62)2	63)3	64)4	65)2	66)3	67)4	68)2	69)3	70)4

Ex – 2

1)1	2)4	3)3	4)3	5)2	6)1	7)1	8)3	9)4	10)2
11)3	12)2	13)1	14)3	15)4	16)1	17)2	18)2	19)1	20)2
21)2	22)1	23)3	24)1	25)4	26)3	27)2	28)4	29)4	30)1
31)2	32)3	33)2	34)1	35)3					

FLOWER
MULTIPLE CHOICE

Exercise – 1

1) Founder of Sexual system of classification also defined flower as a modified shoot is
    1) Scientiest introuduced binomial nomenclature
    2) Scientiest coined and term taxonomy
    3) Scientiest popularized binomial nomenclature
    4) Scientists popularized natural classification
2) Number of internodes and nodes found in a typical angiospermic flower is respectively
    1) 4, 3 2) 2, 2 3) 3, 3 4) 3, 4
3) Floral leaves are arranged at
    1) internodes of condensed shoot
    2) nodes of uncondensed shoot
    3) terminal part of uncondensed shoot
    4) nodes of condensed shoot
4) The position of non-essential organs in a flower respectively is
    1) first, second internodes 2) second, third nodes
    3) first, second nodes 4) third, fourth nodes
5) The position of calyx and gynoecium in a typical flower respectively is
    1) first and fourth nodes 2) second & fourth nodes
    3) third and first nodes 4) first & fourth internodes

6) Type of sex-distribution found in a plant showing a special type of alternate phyllotaxy and catkin interforescence is
1) Dioecious 2) Polygamous 3) Monoecious 4) 1 & 3
7) A tree which produces cauline leaves with palmate parallel divergent venation consists of
1) bisexual flowers 2) neutral flowers
3) either male (or) female flowers 4) only female flowers
8) Hydrophytic dioecious plant is
1) Nymphaea 2) Vallisneria 3) Victoria 4) Ranunculus
9) Spirocyclic flowers born on older stem is
1) Annona 2) Polyathia 3) Artocarpus 4) 1 & 2
10) Both unisexual and bisexual flowers are present on the same
1) plant contain inverted ovule 2) plant contain straight ovule
3) plant, which Strasburger discovered monosporic type of embryosac
4) 2 & 3
11) According to phylogeny, in primitive flower
1) All the floral are arranged in circles on the thalamus
2) Perianth lobes are arranged in whorls
3) All the floral parts are arranged spirally on the thalamus
4) Essential organs are arranged in whorls
12) The arrangement of first floral leaves and last floral leaves respectively in a plant which produces etaerio of berries which resembles a single fruit is
1) cyclic, spiral 2) spiral, cyclic 3) spiral, spiral 4) cyclic, cyclic
13) Generally these floral parts are taken into consideration for merosity
1) calyx, androecium 2) corolla, gynoecium
3) Androecium, gynoecium 4) calyx, corolla
14) Based on merosity, advanced flower is
1) tetramerous 2) pentamerous 3) trimerous 4) 1 & 2
15) Actinomorphic flower exhibit
1) radial symmetry 2) bilateral symmetry
3) binal symmetry 4) cubical symmetry
16) The plant produces assymetric flower is
1) Cassia 2) Canna 3) Crocus 4) Cajanus
17) Zygomorphic nature of Dolichos flower is due to
1) Calyx 2) Anderoecium 3) Corolla 4) Gynoecium
18) Hypogyny to epigyny is observed in
1) first sub-class in Dicotyledonae of Bentham & Hooker classification (B/H)
2) first sub-class is monocotyledonae of B/H classification
3) second sub-class in gymnospermae of B/H classification
4) third sub-class in dicotyldonae of B/H classification
19) The mode of arrangement of perianth lobes in bud condition is called
1) vernation 2) aestivation 3) venation 4) placentation
20) Aestivation type is outer and inner whorls of perianth in Hibiscus respectively is
1) Twisted, valvate 2) Twisted, imbricate
3) Imbricte, twisted 4) Valvate, valvate
21) Minimum & maximum overlapping of perianth lobes are noticed respectively in
1) Quicunicial, Twisted 2) Twisted, Quincunicial
3) Imbricate, Valvate 4) Twisted, Valvate
22) Overlapping is antero-posterior in
1) corolla of Fabaceae 2) calyx of Caesalpinaceae

3) corolla of Caesalpinaceae 4) calyx of Malvaceae

23) Special type of twisted aestivation is
1) valvate 2) asecendingly imbricate
3) deescendingly imbricate 4) quincuncial

24) Aestivation with 1 + 1 + 3 overlapping method is called
1) quincuncial 2) descendingly imbricate
3) ascendingly imbricate 4) 2 & 3

25) Aestivation with 2 +2 + 1 overlapping method is called
1) valvate 2) twisted 3) imbricate 4) quincuncial

26) Regular overlapping of perianth lobes is seen in
1) Calyx of Annona 2) Corolla of Hibiscus
3) Corolla of Datura 4) 2 & 3

27) Petaloid bracts are found in
1) Bignonia 2) Butea 3) Bongainvillea 4) Borassus

28) Overlapping of petal margins proceeds downwards from axis side to bract side of the flower is found in this aestivation
1) Ascending imbricte 2) Vexillary
3) Quincuncial 4) Valvate

29) Extended tip of thalamus between two carpels is called
1) gynophore 2) carophore 3) anthophore 4) androphore

30) Incomplete bisexual flower is
1) Tridax – disc floret 2) Tagentus – ray floret
3) Xanthium – disc floret 4) Helianthus – ray floret

31) Carpophore is noticed in
1) Lamiaceae 2) Apiaceae 3) Euphorbiaceae 4) Orchidaceae

32) Calyx falls before fertilization in
1) Acacia 2) Asparagus 3) Argemone 4) Annona

33) Persistent calyx which does not grow along with growth of fruit is called
1) Cauducous 2) Marscescent 3) Accrescent 4) Pappus

34) Accrescent calyx is noticed in
1) Sun berry 2) Goose berry 3) Indian goose berry 4) 1 &2

35) Polypetalous, actinomorphic corolla is seen in
1) Malavaceae 2) Solanaceae 3) Fabaceae 4) 1 & 2

36) Inner whorl of non-essential organs are present at
1) Fourth node 2) Second node 3) First node 4) Third node

37) Pappus is
1) Reduced hairy corolla, useful in dispersal of fruit by water
2) Reduced hairy calyx, useful in dispersal of seed by wind
3) Reduced hairy calyx, useful in dispersal of fruits by water
4) Reduced hairy calyx, useful in dispersal of fruits by wind

38) The andoroecium is
1) The third whorl of lower 2) The first whorl of perianth
3) The first whorl of essential organs 4) 1 & 3

39) Stamens are also called
1) Megasporophylls 2) Prophylls
3) Sporophylls 4) Microsporophylls

40) Hooded stamen is present in
1) Aristolochia 2) Tagetus 3) Cassia 4) Tridax

41) Sterile stamen is known as
1) Staminode 2) Gall stamen 3) Pistillode 4) Sterile carpel

42) The morphology of hood in a microsporophylly of Vernonia is
1) Filament 2) Connective 3) Anther 4) Microporangia
43) Reniform, monothecous anther is found in
1) Tridax 2) Hibiscus 3) Datura 4) Dolichos
44) Valvular dehiscence is seen in
1) Complete stem parasite 2) Incomplete root parasite
3) Complete root parasite 4) Incomplete stem parasite
45) Minimum damage of anther will during dehiscence is noticed in
1) Cassytha 2) Solanum 3) Datura 4) Hibiscus
46) When the dehiscence of anthers occurs towards the outside of the flower, the condition is called
1) Exerted 2) Extrorse 3) Inserted 4) Introrse
47) Extrorse condition is seen in
1) Datura 2) Hibiscus 3) Dalbergia 4) Primula
48) Type of dehiscence in Datura is
1) Longitudinal, introrse 2) Longitudinal, extrorse
3) Longitudinal, exerted 4) Transverse, introrse
49) Single whorl of stamens are antisepalous in
1) Datura 2) Vernonea 3) Tagetus 4) 1 & 2
50) In Calotropis, stamens adhere to
1) Sepals 2) Style 3) Stigma 4) Ovary
51) Stamens arranged in single, whorl, alternating with petals is called
1) Haplo stemonous 2) Diplostemonous
3) Obdiplostemonous 4) 2 & 3
52) Both fertile part & sterile part of all microsporophylls are united in
1) Hibiscus 2) Datura 3) Cucurbita 4) Tridax
53) Actinomorphic flower with monadelphous condition is found in
1) Crotalaria 2) Arachis 3) Hibiscus 4) All
54) Zygomorphic flower with monadelphous condition is present in
1) Crotalaria, Hibiscus 2) Crotalaria, Ruscus
3) Crotalaria, Arachis 4) Crotalaria, Dolichos
55) Number of short stamens found in Ocimum and Brassica respectively is
1) 4, 2 2) 2, 2 3) 2, 4 4) 6, 2
56) Attachment of filament to the whole length of anther is found in
1) Datura 2) Nelumbo 3) Oryza 4) Hibiscus
57) Connective is absent in
1) Datura 2) Abutilon 3) Althea 4) 2 & 3
58) Staminal filament is pointed in
1) Nelumbo 2) Triticum 3) Oryza 4) 2 & 3
59) Pistil is the
1) Innermost whorl of the flower
2) Female reproductive organ of the flower
3) Fourth whorl of the flower
4) All
60) Open carpel is found in
1) First spermatophytes 2) First embryophytes
3) First fruit bearing plants 4) First trachemophytes
61) The reproductive leaves bearing ovules are called
1) microporophylls 2) megasporophylls
3) carpels 4) 2 & 3

62) Open carpel is characterized by
1) presence of ovules 2) absence of ovary wall
3) absence of ovules 4) 1 & 2
63) Bicarpellary and tetracarpellary ovaries are found respectively in
1) Solanum, Ipomea 2) Solanum, Oenothera
3) Tridax, Datura 4) Ocimum, Leucas
64) Apocarpous pistil is present in
1) Nelumbo, Datura 2) Michelia, Calotropis
3) Nelumbo, Michelia 4) Calotropis, Catharanthus
65) Number of carpels and locules exist in 2:1 ration in
1) Datura 2) Tridax 3) Cucurbita 4) Cocos
66) Number of carpels and locules exist in 1:2 ration in
1) Datura, Ocimum, Leucas 2) Tridax, Cucurbita, Leucas
3) Dianthus, Ocimum, Catharanthus 4) Dolichos, Dalbergia, Tridax
67) Number of carpels and locules exist in 1:1 ratio in
1) Dolichos 2) Acacia 3) Mimosa 4) All
68) Maximum number of carpels with least number of locules is found in
1) Dolichos 2) Dianthus 3) Datura 4) Dalbergia
69) Replum is found in
1) Mustard 2) Knol – Knol 3) Capsella 4) All
70) In Dolichos, ovules are arranged as
1) Two rows on ventral suture 2) Two rows on dorsal suture
3) Four rows on ventral suture 4) One row on central placenta
71) Septa in the ovary are ephemeral in
1) Nymphea 2) Dianthus 3) Hibiscus 4) Tridax
72) Type of placentation found in one chambered ovary is
1) Axile, Superficial, basal 2) Marginal, basal, free-central
3) Parietal, Axile, basal 4) Superficial, basal, parietal
73) Placentation transforms from one type to another in
1) Dolichos 2) Dianthus 3) Derris 4) Daucus
74) The ovules are attached to the swollen placental axis in
1) Hibiscus 2) Citrus 3) Allium 4) Lycopersicum
75) Type of placentation found in the gynoecium showing 1:1 ratio of carpels and locules is
1) Axile, marginal, superficial 2) Basal, marginal, Axile
3) Free-central, parietal, Axile 4) Marginal, Axile, free-central
76) Type of placentation found in a plant showing sub-apocarpous pistil with free styles and stigma is
1) Basal 2) Free-central 3) Axile 4) Marginal
77) Many free carpels brought to the same height in
1) Michelia 2) Nelumbo 3) Datura 4) Solanum
78) Many free carpels are arranged spirally on the thalamus in
1) Nelumbo 2) Calotropis 3) Michelia 4) Morus
79) Placentation refers to
1) Arrangement of perianth in bud condition
2) Arrangement of young leaves in bud condition
3) Arrangement of ovaries in bud condition
4) Arrangement of ovules in the ovary
80) In Tridax
1) Carpel and seed exist in same number

2) Carpel and locule exist in same number
3) Locule and seed exist in same number
4) Locule and stamen exist in same number

Keys
Ex- 1

1)3	2)4	3)4	4)3	5)1	6)3	7)3	8)2	9)2	10)4
11)3	12)1	13)4	14)3	15)1	16)2	17)3	18)1	19)2	20)3
21)1	22)3	23)4	24)4	25)4	26)4	27)3	28)2	29)2	30)3
31)2	32)3	33)2	34)4	35)1	36)2	37)4	38)4	39)4	40)4
41)1	42)2	43)2	44)4	45)2	46)2	47)2	48)1	49)4	50)3
51)1	52)3	53)3	54)3	55)2	56)2	57)4	58)4	59)4	60)1
61)4	62)4	63)2	64)3	65)2	66)1	67)4	68)2	69)4	70)1
71)2	72)2	73)2	74)4	75)1	76)2	77)2	78)3	79)4	80)3

FRUITS

- In Angiosperms after fertilization ovary develops in fruit and ovules develop into seeds
- It may be defined as a specific structure formed after fertilization enclosing seed
- Fertilized ovary develops into fruit with in few weeks to several years
- In some plants fruit is formed in about 10 years after fertilization
  Ex: Lodociwa
- In some plants fruit is formed without fertilization this phenomenon is known as parthenocrapy and the fruits are known as parthenocarpic fruits
  Ex: Banana, Pineapple
- Parthenocapic fruit are seedless

Classification of Fruits: On the basis of structure involved in the formation of fruits, structure of pericarp fusion of carpels and dehiscence of fruit, fruits are classified into false and true fruits

False Fruits: Develops from any other part of the flower except ovary.
Ex: Apple, Pear, Anacardium

- Apple and Pear – thalamus develops into false fruit
- Analaudium – pedical develops into fruit

True Fruit: Ovary develops into fruit

- True fruits are classified into: -

i) Simple fruit ii) Aggregate fruits iii) Multiple fruits

Simple Fruit: A fruit that develops from ovary of a syncarpous gynoecium of a single flower is called a simple fruit. These simple fruits are divided into fleshy fruits and dry fruits based on the nature of the pericarp simple fruits are classified into

Fleshy Fruits:

- Fruits are scculent and juicy at maturity
- They do not dehiscence. Seeds are liberated after the decay of pericarp
- Pericarp can be distinguished into epicarp, mesocarp and endocarp

Types of Fleshy Fruits:

1) *Berry*: Fleshy fruit with hand seeds

- Develops from bicarpillary or multicarpellary, synlarpous superior or inferior ovary
- Pericarp is smooth and scculent
  Ex: Tomato, Brinjal, guava, banana etc
- Pericarp is differenciated into epicarp, mesocarp and endocarp

2) *Pome*: It is a fleshy fruit developed from multi-carpellary syncarpous inferior ovary
- Thalamus becomes fleshy & swollen (false fruit) & completely surrounds the true fruit
  Ex: Apple i.e. pyrus malus
  Pear i.e. pyrus communics

3) *Pepo*: It is fleshy fruit which develops from tricarpellary unilocular, inferior ovary
- Pericarp is differenciated into epicarp, mesocarp and endocarp
- Epicarp is fused with thalamus and forms hard skin known as rind
- Mesocarp and endocarp are pulpy, seeds are attached to placenta
  Ex: Cucurbitaceae members

4) *Hespiridium*: Fleshy fruits that develops from multicarpellary, multilocular, syncarpous superior ovary
- Pericarp is differenciated into epicarp, mesocarp and endocarp
- Epicarp is leathery and glandular, mesocarp is thin and smooth
- Epicarp and mesocarp inwards and forms many chambers
- Several juicy hairs develops from endocarp
  Ex: Citraceae members

5) *Drupe*: It is a fleshy fruit that develops from monocarpellary or tricarpellary, syncarpous ovary
- It is one second fruit with thin or skinny epicarp, fibrous mesocarp and stony endocarp
- Due to the presence of hard and stony endocarp drupe is also known as stone fruit
  Ex: Mango, Coconut

Dry Fruits: The fruits in which pericarp becomes dry at maturity are dry fruits pericarp is brittle or hard.
On the basis of dehiscence dry fruits are classified into:-
a) Dry dihscent b) Dry indhiscent c) Schizocarpic fruits

Dry Dehiscent Fruits: These fruits dehise automotical at maturity and liberate seeds on the basis of dehiscen of pericarp they are again classified into:-
i) Legume
ii) Follicle
iii) Siliqua
iv) Silicula
v) Capsule

i) *Legume*: Develops from monocarpellary, unilocular superior ovary
- Pericarp spilts dousoventrally from bath sulure into tow halves
  Ex: Members of Leguminasae

ii) *Follicles*: It develops from bicarpellary, syncarpous unilocular superior ovary
- Pericarp spilts along ventral suture only
- Seeds are attached to placenta
  Ex: Calotropis, Catharanthus, Bomksia, Makua

iii) *Siliqua*: Develops from bicarpellary, Syncarpous, Superior ovary
- Ovary is unilocular but becomes bilocular due to the development of ruplum
- Pericarp spilts dorsoventrally into two halves from base to apex
- Seeds remouis attached to the replum

Ex: Members of Brassicaceae

iv) Silicula: Short and flathened sliqua with less number of seeds is known as Silicula
Ex: Capsella brusa – pastoris, Lunario etc

v) *Capsule*: It develops from multicarpellary, synacarpous superior or Inferior ovary

- Based on the mode of dehiscence capsule are classified into
  a) Loculicidat capsule
  b) Septicidal capsule
  c) Septifrogal capsule
  d) Porous capsule
  e) Pycis / Pyridium

a) *Loculicidal Capsule*: Splits along the dorsal suture of caeh locule.
Each locule splits through the middle portion.

- Number of values are equal to the number of carpels
- Seeds are attached to innerpart of each locule
  Ex: Gossypium, heubacium, Abelmoschus esculents

b) *Septicidal Capsule*:

- Pericarp splits the septa present between the locules
- Number of values are equal to number of carpels
  Ex: Aristolochia, Colchicum, Digitalis

c) *Septifrogual Capsule*:

- Pericarp spilts speticidally or localicidally
- Seeds remain attached to the central swollen placental axis
  Ex: Datura, Impartiens

d) *Porous Capsule*: Many small pores formed specific position of ripened fruit

- It develops from superior ovary. It shows pores at its apex.
  Ex: Papaver, Antirhinum
- Porous capsule formed from inferior ovary show pors at the base.
  Ex: Companula, Leudwegia

e) *Pyxidium (Pyxis)*:

- Pericarp splits transversely, upper part comes out as lid exposing the seeds
- Seeds are present in the lower part
  Ex: Amaranthus, Portulaea

ii) ***Dry indehiscent fruit***: These dry fruits are normal one seeded and never dehisce even at mature. The seeds are liberated out only after the disintegration of the pericarp. These fruits are of five types

1) *Achene*: This dry indehiscent fruit is developed from unilocular, superior ovary of monocarpellary .The pericarp and seed coat remains free
Ex: Gynoecium Mirabilis

2) *Caryopsis*: It is similar to aehene but the pericarp and seed coat fuse poaleae.
Ex: Oxyza and Triticum

3) *Cypsela*: It is one seeded fruit developing fromunilocula inferior ovary of bicarpellary, sycanpous gynoecium.
This fruit is characterised persistent pappus like calyx. It is the characteristic fruit of steraleae
Ex: Tridax procumbers and Tagetus patula

4) *Nut*: It is dry indehiscent fruit developing from unilocular bi or multicarpellory, syncarpons gypoecium. This fruit is characterised by a stony pericarp.
It encloses a single seed. The pericarp and the seed coat remain free.
Ex: Anacardium occldentalis

5) *Samara*: It is winged dry indehiscent fruit developed from superior ovary of bi or tricarpellary, Syncarpous gynoecium. The wings are developed from the pericarp and they help in dispersal
Ex: Hiptage, Gyrocarpus, Ventilago

iii) ***Schizocarpic Fruits***:

- These are the dry fruits which show the characters of both the dehiscent as well as indehiscent fruits. At maturity the fruit splits up into many one-seeded bits called Mericarps. The seeds present in the mericarps are liberated only after the disintegration of the period. These fruits are of the following six types. They are

1) *Lomentum*: It is developed from ovary of monocarpellary gynoecium like alegume. The fruit is constrictud between seed. At maturity the fruit dehisces on the constriction many mericarps. The fruit are formed common in the members of family mimosae
Ex: Acalia and μ
2) *Schizocarp*: It is a Schizocarpic fruit developing from multilocular, superior ovary or multicarpellary, syncay gynoecium. At maturity it splits into many mericory. Each mericory contains either one or many seeds. This fruit is found in members of Malvaceae family
3) *Carcerulus*: It is a dry Schizocarpic fruit developing from tetralocular superior ovary of bicarpellary, sycaupous gynoecium. At maturity the fruit dehisces into four nutlets
Ex: Ocimum
4) *Regma*: It is Schizocarpic fruit which develops from trilocular, superior ovary of tricarpellary, syncarpous gynoecium. At maturity the fruit splits into three one seeded mericarps called occi
Ex: Ricinus communos
5) *Cremocarp*: It is developed from bilocular, inferior of bicarpellary, syncarpous gynoecium. In between the carpels a carpophore is present which is an elongated thalamus. At maturity the fruit dehisces into two one – seeded mericarps attached to the carpophore. It is the characteristic fruit of apiacuae.
Ex: Coriandaum balivum
6) Double Saniara: It is a Schizocarpic fruit developing from superior ovary of bicarpellary syncarpous gynoecium. The fruit dehisces into two sanuara like mericarps.
Ex: Acer

II ***Aggregate Fruits***: The fruits which develops from multicarpellary, apocarpous ovary of single flower known as aggregate form.

- In aggregate fruits each carpel develops into fruit let
- In some plants fruit lets fuse together and gives the appearance of single fruit
  Ex: Annona
- In many plants, fruit lets remain free from one another, forming a bunch of fruit lets known as etario of fruit lets

Ex: Etario of achenes - Naravellia, Nelumbo
Etario of berrier - Polyathia, Artabotrys
Etario of drupes – Rubus
Etario of follices – Mangolia
Etario of samora – Acer

Multiple Fruits / Composite Fruits:

- It develops from inflorescence

- Each flower develops into small fruit
- Peduncle becomes fleshy, all the fruits fuse with the fleshy peduncle and forms multiple fruit
- On the basis of type of inflorescence, multiple fruits are of two types
  i) Sorosis   ii) Syconus

i) *Sorosis*: Ex: Artocarpus, Ananus sativus, Morus

- Develops from spike or spadix inflorescence
- Peduncle and floral parts fuse to form multiple fruits
- Peduncle becomes fleshy or woody
- In Artocarpus integriflolia (Jack fruit), peduncle is club shaped, perianth is fleshy and edible
- In Ananas Sativus (Pineapple), peduncle is fleshy polygonal patches represents the fused which are fused together. Leafy structures on the top are sterile bracts
- In morusalba (mulberry) multiple fruits encloses fleshy perianth enclosing dry achenes

ii) *Syconus*: Ex: Ficus, Dorstenia

- Develops from hypanthodium inflorescences
- Peduncle is fleshy, hollow cup like and is edible
- Female flowers develops into achenes

Unit -III
REPRODUCTION IN PLANTS

- Each and every organism can live only for a certain period of time. The period from birth to the natural death of an organism represents its **life span.**
- **Reproduction** is defined as a biological process in which an organism gives rise to young ones (offspring) similar to itself. The offspring grow, mature and in turn produce new offspring. Thus, there is a cycle of birth, growth and death.
- Reproduction enables the continuity of the species, generation after generation.
- When offspring is produced by a single parent with or without the involvement of gamete formation, the reproduction is **asexual.**
- When two parents (opposite sex) participate in the reproductive process and also involve fusion of male and female gametes, it is called **sexual reproduction**.

ASEXUAL REPRODUCTION

- In this method, a single individual (parent) is capable of producing offspring. As a result, the offspring that are produced are not only identical to one another but are also exact copies of their parent.
- Asexual reproduction is common among single-celled organisms, and in plants and animals with relatively simple organisations. In Protists and Monerans, the organism or the parent cell divides into two to give rise to new individuals. Thus, in these organisms **cell division** is itself a mode of reproduction.
- Many single-celled organisms reproduce by **binary fission,** where a cell divides into two halves and each rapidly grows into an adult (e.g., *Amoeba, Paramecium*). In yeast, the division is unequal and small **buds** are produced that remain attached initially to the parent cell which, eventually gets separated and mature into new yeast organisms (cells).
- Members of the Kingdom Fungi and simple plants such as algae reproduce through special asexual reproductive structures.
- The most common of these structures are **zoospores** that usually are microscopic motile structures. Other common asexual reproductive structures are **conidia** (*Penicillium*), **buds** (*Hydra*) and **gemmules** (*sponge*).
- In plants, the term **vegetative** reproduction is frequently used. In plants, the units of **vegetative propagation** such as **runner, rhizome, sucker, tuber, offset, bulb** are all capable of giving rise to new offspring. These structures are called **vegetative propagules.**

SEXUAL REPRODUCTION

- Sexual reproduction involves formation of the male and female gametes, either by the same individual or by different individuals of the opposite sex. These gametes fuse to form the zygote which develops to form the new organism.

- It is an elaborate, complex and slow process as compared to asexual reproduction. Because of the fusion of male and female gametes, sexual reproduction results in offspring that are not identical to the parents.
- All organisms have to reach a certain stage of growth and maturity in their life, before they can reproduce sexually. That period of growth is called the **juvenile phase**. It is known as **vegetative phase** in plants.
- The females of placental mammals exhibit cyclical changes in the activities of ovaries and accessory ducts as well as hormones during the reproductive phase.
- In non-primate mammals like cows, sheep, rats, deers, dogs, tiger, etc., such cyclical changes during reproduction are called **oestrus cycle** where as in primates (monkeys, apes, and humans) it is called **menstrual cycle**.
- Sexual reproduction is characterised by the fusion (or fertilisation) of the male and female gametes, the formation of zygote and embryogenesis. For convenience these sequential events may be grouped into three distinct stages namely, the **pre-fertilisation, fertilisation** and the **post-fertilisation events.**
- Pre-fertilisation Events of sexual reproduction prior to the fusion of gametes. The two main pre-fertilisation events are **gametogenesis** and **gamete transfer.**
- **Gametogenesis** refers to the process of formation of the two types of gametes – male and female. Gametes are haploid cells. In some algae the two gametes are so similar in appearance that it is not possible to categorise them into male and female gametes. They are hence, are called **homogametes** (**isogametes)**.
- Sexually reproducing organisms the gametes produced are of two morphologically distinct types (**heterogametes).** In such organisms the male gamete is called the **antherozoid** or **sperm** and the female gamete is called the **egg** or **ovum Sexuality in organisms.**

SEXUAL REPRODUCTION IN FLOWERING PLANTS

- The branch of science that deals with the study of development of zygote into embryo is "embryology"
- Embryology is also concerned with development of male & female gametophytes, process of fertilization & development of embryo & endosperm
- Angiospermic plants shows two stages in their life ---
  i) Sporophytic phase ii) Gametophytic phase

  i) Sporophytic phase:
- Angiosperms are diploid sporophytes
- It develops from zygote

  ii) Gametophytic phase:
- Zygote produce haploid spores after reduction division or meiosis.
- Spores are of two types

Microspores	Megaspores
(pollen grains)	(embryo sac)
1) are produced in	1) megaspores are produced in

microorganium
2) They germinate to produce male gametophyte
3) male gametophyte produce two male gametes

megasporangium (ovule)
2) It is also known as female gametophyte
3) It contains egg

- One male gamete fuses with egg & forms zygote
- Zygote divides repeated by mitotic division & forms embryo
- Second male gamete fuses with diploid secondary nucleus to form triploid primary endosperm nucleus (PEN)
- Primary endosperm nucleus divides by mitotic division & produce endosperm (3n).
- Endosperm supplies nourisment to developing embryo, Which develops into diploid sporophyte.

MICROSPOROGENESIS & DEVELOPMENT OF MALE GAMETOPHYTE

Structure of Stamen:

- Stamens are the male reproductive organ. It consists of anther & filament.
- Anther & filament are connected with the help of connective
- Anther may be
  - monothecous $\rightarrow$ monocots
  - dithecons $\rightarrow$Dicots
- Monothecous anther is one lobed & consists of two microsporangia
- Dithecous anther is two lobed & consists of four microsporangia
- Mature microsporangium consists of micro sporangia surrounded by anther wall
- Anther wall consists of epidermis, endothecium, wall layers & tapetum
- Epidermis is outermost, protective layer
- Epidermal cells present between two pollen sac are thin walled & forms stomium
- Stomium helps in dehiscence of sporangium
- Endothecium is present beneath the epidermis
- Cells of enodthecium are elongated & shows fibrous bands
- Fibrous bands are hygroscopic when these cells loose water, they contract & helps in dehiscence
- Wall layers (middle layers): 1 – 3 wall layers are present beneath the endothecium, stores food.
- Tapetum: It is the innermost layer of anther wall.
- It surrounds the sporgenous tissue
- Cells cytoplasm are large, thin walled & contains dense cytoplasm & prominent nuclei
- Tapetum is nutritive tissue & supplies nutritive materials to the sporogenous tissue

- At the time of anther dehiscence, tapetum degenerates only rements of tapetum can be observed in the dehiscised anther
- Sporogenous tissue: It is present inner to the tapetum
- the cells directly acts as pollen mother cells or microspore mother cells
- microspore mother cells divided meiotically & produce haploid microspores or pollen grains by the process of microsporogenesis

Structure of Pollen grains:
- Pollen grains i.e. microspores are haploid
- It is the first cell of male gametophyte
- It is oval or spherical in shape & is surrounded by thick stratified wall known as sporoderm
- Sporoderm consists of two layers

Exine	Intine
1) Outer thick layer made up of sporopollenin	1) Inner thin layer
2) protects the pollen grain from damage & dessication	2) It is made up of pectin & cellulose
3) It may have waxy coating	3) It forms pollen tube
4) It has some thinner circular spots known as germ pores.	

- Sporoderm encloses dense cytoplasm with centrally located nucleus.

Development of Male Gametophyte:
- Microspore /pollen grain is the 1st cell of male gametophyte
- It divides periclinally & produce two unequal cells
- Larger cell is known as vegetative cell & smaller cell is known as generative cell.
- At two celled stage pollen grains i.e. male gametophytes are liberated from the anther.
- The pollen grains germinate on reaching stigma
- During germination, intine produces pollen tube throughout the germ pore
- Normally one pollen tube is produced from pollen grains →monosiphonours pollen grains
- In Malvaceae & Cucurbitaceae members more than one pollen tube is formed →polysiphonous pollen grains
- The content of pollen tube enters into the pollen
- Generative cell divides nitotically & produce two male cells / sperm cells
- At this stage pollen tube contains two sperm cells & one vegetative cell
- Vegetative cell gradually disappers
- Pollen tube passes throughout the style & reaches the ovule

OVULE, MEGASPOROGENESIS
DEVELOPMENT OF EMBRYO SAC

- Ovule is integumented megasporangium
- It consists of nucellous which is surrounded by one or two integuments
- Integuments leave a small opening at the apical end known as microphyle
- Near the basal region, integuments & funicle are fused together which is known as chalaza
- The ovule is attached to the placenta with the help of stalk called as funicle
- Integuments are protective in function.
- Based on the number of integuments ovules are ----
  i) Ategmic ovules – ovule with naked nucellus Ex: Loranthus, Balanophora
  ii) Unitegmic ovules – ovule with one integument
  Ex: monocots & polypetalae members of dicots
- Nucellus encloses embryo sac which is known as female gametophyte
- Nucellus may be small or massive
- Based on the quantity of nucleus, ovules are classified into two types ---
  i) Tenuinucellate ovules ii) Crassinucellate ovules
- <u>Tenuinucellate ovules</u>:
- Single hypodermal cell of the nucellus is differenciated into archesporial cell which directly functions as megaspore mother cell
- Hence nucleus is represented by few cells arranged in a single layer
  Ex: Members of Gamopetalae & Monochlamydae (i.e. Rubiaceae, Orobanchaceae)
- <u>Crassinucellate ovules</u>:
- Single hypodermal cell of the nucellus is differenciated as archesorial cell, which divides transversely to form upper primary parietal cell & lower primary sporogenous cell.
- Primary parietal cell divides periclinally & anticlinally to produce massive nucellus.
  Ex: Members of polypetale & monocots (Cucurbitaceae, Malvaceae)

<u>Types of Ovules</u>: Based on the position of microphyle with respect to funicle, ovules are classified into---

i) <u>Orthoprous Ovules</u>: It is erect or straight ovule.
- Micropyle, chalaza & funicle in same verticle line
  Ex: Piperaceae , Polygonaceae (Polygonum)

ii) <u>Anatropous Ovules</u>: Inverted ovule (180^0 curvature)
- Body of the ovule is completely inverted due to unilateral growth of funicle
- Micropyle & funicle come close to each other
- Micropyle & chalaza is in same verticle line
  Ex: Polypetae, Gamopetalae, Manocots (Helianthus, Tridax etc)

iii) <u>Hemitropous / Hemianatropous</u>:
- Body of the ovule is at right angle to funicle.

Ex: Ranunculus, Primula (Malpighiaceae, Primulaceae)

iv) Campylotropous Ovules:

- Body of ovule is at right angle to funicle
- Micropylar parts curves down wards & come nearer to the funicle. Embryo sac is straight Ex: Fabaceae, Brassicaceae, Capparadiceae

v) Anphitropus Ovule: (160^0 curvature)

- Body of the ovule shows more curvature
- Embryosac becomes horse- shoe shaped
- micropyle & chalaza are brought nearer

  Ex: Alismaceae, Butomaceae

vi) Circinotropous Ovule:

- Funicle is long & coil like watch spring around the ovule Ex: Opuntia

Megasporogenesis & Development of Embryo Sac:

- One or more cells of nucellus develops into archesporial cells.
- Archesporial cell (2n) undergo periclinal division to produce outer primary parietal cell & inner primary sporogenous cell
- Primary parietal cell divides repeatedly & produce wall layers
- Primary sporogenous cell directly functions as megaspore mother cell
- Diploid megaspore mother cell undergo megasporogenesis. It divides by meiosis & forms four, haploid megaspores, which are arranged in linear tetrad
- Out of four megaspores, upper three megaspores are non functional & hence degenerate
- Functional megaspore enlarges in size, the haploid nucleus undergo three free nuclear mitotic divisions & produce eight haploid nuclei (arranged in two groups of four each at each pole). At this stage megaspore is known as embryo sac
- Out of four nuclei situated at micropylar end three nuclei organise to form “egg apparatus” the fourth nucleus is considered as “upper polar nucleus”
- Out of four nuclei preset at chalazal end, three nuclei organise into antipodal cell & fourth nucleus is regarded as “lower polar nucleus”
- The two polar move towards the center of embryo sac & fuse to form “diploid endosperm nucleus”
- The eight nuclei of embryo sac are arranged in 3+2+3 condition
- Now cell walls are formed around each nucleus & embrosac represent 7 celled & 8 nucleate condition & is also known as “female gametophyte”
- The embryo sac is developed from single megaspore & hence it is described as “monosporic embryosac”

Structure of Embryo Sac (i.e. female gametophyte):

- In Angiosperms female gametophyte is known as embryo sac. It is seven celled & eight nucleate structure
- It is known as Polygonum types as it was first studied in Polygonum divericatum by Strassbuger (1879)
- Embryo sac consists of ----

  i) Egg apparatus

ii) Antipodal cells
iii) Central cell

i) Egg Apparatus: Present towards micropylar end

- It consists of three cells
- The central cell of egg apparatus is big & is considered as ‘egg’. It shows large nucleus towards lower side & vacuole towards upper side
- The two cells present on either side of egg are known as ‘synergids’, are hooked towards upper side
- Synergids shows fibre of finger like structures known as filiform apparatus
- Filiform apparatus helps in absorption & conduction of food materials from nucleus to embryosac. They also helps in directing the entry of pollen tube into embryo sac

ii) Antipodals: present at the chalazal end

- They are smaller than the cells of egg apparatus
- They are regarded as the vegetative cells of embryo sac
- They are ephemeral & degenerate before or after fertilization

iii) Central cell: largest cell of embryo sac

- It shows large central vauiole & two, haploid polar nuclei
- The two polar nuclei fuse of form diploid secondary nucleum
- fusion takes place during the entry of pollen tube into the embryo sac or after the entry of pollen tube into the embryo sac

POLLINATION

- Transfer of pollen grains from anther to stigma of a flower is known as pollination
- In Gymnosperms, pollen grains are directly deposited on the ovule→direct pollination
- In Angiosperms, pollen grains are deposited on the stigma as ovule is enclosed inside the ovary Such pollination is known as “indirect pollination”.
- Pollination is so important that fertilization can not takes place without pollination
- The study of different pollination mechanism & relationship between flowers & pollinators is known as ‘Pollination biology”

Kinds of Pollination: Two kinds of pollination are---
Cliestogamy – Ex: Commelina, Oxalis, Cardamine
Chasmogamy – Ex: Datura, Hibiscus

REPRODUCTION IN PLANTS

Pollination

Chasmogamy
Pollination in opened flowers
Commelina

Cliestogamy
pollination in closed flowers
Ex: Oxalis, Subularia,
Cardamine

Allogamy
transfer of pollen grains from
anther of one flower to stigma of
another flower

Autogamy
transfer of pollen grains from
anther to stigma of same flower

Geitomogamy
Cross pollination between two
flowers
flowers of same plant
species
(Genetical self pollination Ex: Maize)

Xenogamy (true cross pollination)
Cross pollination between two
of two different plants of same

<u>Advantages of Cross Pollination</u>:

- Plants obtained by cross pollination exhibits variation as there is mixing up of characters of two different parents. Variation is the basis for evolution of new species.
- Plants developed by cross pollination are usually good, healthy, resistant to disease, pest & drought
- Productivity is much more when compared to other varities
- Plants grows vigrously in different agronomical conditions
- They produce good & healthy seeds suitable to raise new crops

<u>Contrivancies of Cross Pollination</u>:

- Flowers show special adaptations/contrivancies to ensure cross pollination

1) <u>Dicliny (or) Unisexuality</u>: Production of unisexual flowers is dicliny

- Some plants produce staminate & pistillate flowers separately. In such unisexual flowers cross pollination takes place
- Monoecious condition – male & female flowers are present on the same plant
  Ex: Cocos, Cucurbita, Zea, Colocasia
- Dioecious condition – male & female flowers are present on separate plants
  Ex: Carica, Vallisneria, Borassus
- Polygamous condition – male, female & bisexual flowers are present on same plant
  Ex: Mangifera

2) <u>Dichogamy</u>: “ripening of male & female reproductive organs of a flower at

different time".

- It is of two kinds

a) Protandry: "androecium matures earlier than gynoecium"
Ex: Helianthus, Saxifraga, Gossypium, Clerodendron, Phlox

b) Protogyny: gynoecium matures earlier than androecium
Ex: Solanum, Polyalthia, Annona, Prosopis, Helleborus

3) Herkogamy: "Arrangement of androecium & gynoedcium at different heights".
Ex: Hibiscus, Gloriosa

4) Heterostyly: "presence of styles with different lengths in a flower of same species".

- It is of two types -----

a) Diheterostyly: "presence of styles of two different lengths in dimorphic flowers of same species".
Ex: Oxalis, Oldenlandia, Primula

- Flowers are dimorphic. In first type of flowers, stamens are long & style is short
- In Second type of flowers stamens are short & style is long
- Cross pollination occurs between style & stamens of the same length
- Dimorphic flowers shows dichogamy & herkogamy

b) Triheterostyly: " presence of styles of three different lengths in different flowers of the same speices". Flowers are trimorphic
Ex: Lathyrum, Biophytum

5) Self Sterility: "pollen grains fails to germinate on the stigma of the same flower".
Ex: Passiflora, Malva, Abutilon

- Flowers may wither away if self pollination occurs Ex: Orchids

6) Pollen Prepotency: stigma receives the pollen form the same flower as well as
from another flower of same species simultaneously foreign pollen grains germinate earlier. Ex: Bean & other members of Fabaceae

7) Sensitive stigma: Stigmatic lobes are sensitive.

- When cross pollination occurs, stigmatic lobes come closer to prevent self pollination Ex: Martynia, Mimulus

Agents of Cross Pollination:

- Anemophily: Pollination by wind
- Hydrophily: Pollination by water

Epihydrophily	Hypohydrophily
Hydrophily on the water surface	Hydrophily inside water
Ex: Vallineria, Ruppie, Elodea, Callitriche	Ex: Zostera, Naias, Ceratophyllum

- Zoophily: Pollination by animals
- Ornithophily: Pollination by birds Ex: Bignonia, Delonix, Erythrina, Salmalia etc

- Chiropteriphily: Pollination by bats. Ex: Bauhinia, Oroxylum, Musa, Anthocephalus
- Malacophily: Pollination by snails Ex: Arisaema
- Entomophily: Pollination by insects Ex: Canna, Callistemon

Self Pollination: "Transfer of pollen grains from anther to stigma of same flower".

1) Homogamy: Maturation of androecium & gynoecium at the same time in a bisexual flower. Ex: Ranunculus, Catha
2) Movement of floral parts: In flower with epipetalous stamens, petals move & make the anther to come in contact with the stigma.

- In Argemone, pollen adhers the inner surface of petals which shows sleeping movement.

3) Incomplete Dichogamy: In flowers showing dichogamy there may be a short time when anther & stigma are fertile, at that time self pollination takes place Ex: Liliaceae, Armaryllidaceae
4) Safety Mechanism: When cross pollination fails to occur stigmatic lobes bend down & touch the anther to carryout self pollination Ex: Asteraceae
5) Cliestogamy: In cliestogamy flowers the pollen grains are shed with in the closed flower & carryout self pollination Ex: Saliva, Commelina, Lamium, Oxalis

Additional information :

- Anemophily: Pollination by wind
- Plants bearing anemophilous flower may be short (grasses) or tall (palms)
- Some special features to ensure wind pollination are ----
- Flowers are inconspicuous & not showy
- They lack scent or nectar
- Inflorescence may be spike, catkin or spadix
- Flowers produce large quantity of dusty pollen
- Perianth lobes are reduced & sex organs are elaborate
- Stamens with long drooping filament
- Anther shows versatile fixation
- Pollen grains are small, dry smooth & very light in weight. In Pinus pollen grains are winged
- Pollen may be released with some force (gun powder mechanism) Ex: Pilea
- Stigma is branched & brush like for catching the pollen from air
- Hydrophily: Pollination by water
- True hydrophily occurs only in submerged hydrophytes
- Hydrohilous flowers produce long needle like pollen grains. Usually they lack exine.

a) Epihydrogamy: Pollination on the surface of water
Ex: Vallisneria, Ruppia, Elodae, Calliriche

- Vallisneria produce floats on water after detaching from spadix inflorescence
- Female flowers are solitary long with spirally coiled pedicel

- At maturity female flowers comes to water surface
- Anther & stigma cones in contact on the water surface
- After pollination female flowers are pulled down due to coiling of pedicel
- Fertilization is below water surface

b) Hypohydrogamy: Pollination below water surface
Ex: Zostera, Naias, Ceratophyllum

- Zostera produce needle like pollen grains
- When they liberate from anther, they are suspended in water
- Long style with sticky stigma catches the pollen grains to facilitate pollination
- Entomophily: Pollination by insects
- Majority of flowers are insect pollinated
- Bees, flies, butter flies & moths are common insects which helps in pollination
- They visit the flower for honey & pollen
- Entomophilous flowers shows certain adaptations to attact the insects

1) Colour: flowers are conspicuous & brightly coloured

- Bracts, sepals or stamens become petaloid to attact the insects
- Coloured bracts - Ex: Bougainvillae, Poinsettia
- Petaloid sepal - Ex: Mussaenda
- Petaloid staminod – Ex: Canna
- Coloured filaments – Ex: Callistemon, Enterlobium
- Coloured Corona – Ex: Passiflora, Calotropis

2) Size: flowers are usually bigger in size

- Smaller flowers aggregate to form inflorescences like head or compound heads
  Ex: Mimosa, Tridax, Helianthus etc

3) Scent: flowers which opens at night cannot attact the insects by colour

- They emit characteristic odour to attact insects
  Ex: Nyctanthes, Jasmine, Cestrum, Sterenlia etc

4) Necter:

- Necter is secreted by nectar glands
- Nectaries are situated at the base of the ovary or petals
- Some time extra floral nectaries are also present on bracts or petioles.
  Ex: Passiflora, Hibiscus, Ixora, Thevetia, Milligtonia

5) Pollen:

- Bees collect large amount of pollen during breeding season to nourish their larvae
- In Calotroopis, pollen grains unite to form pollinia
- In Yucca, insect moth “Pronuba yuccacella” collect the pollen & make them into balls before pressing them over stigmatic lobes

FERTILIZATION

- The fusion of male & female gamets is known as "fertilization /syngamy/fecundation".
- In Angiosperms the female gametophyte is deep seated in the ovary
- The male gametophytes (i.e. pollen grains) at two celled stage reaches the stigma by pollination
- They germinate on stigma & produce pollen tubes which grows throughout the style & reach the ovule & release the male gametes into the embryo sac
- Process of fertilization is longer & includes the following steps-----

i) Germination of pollen grains
ii) Entry of pollen tube into the ovule
iii) Fusion of gametes

i) **<u>Germination of Pollen grains</u>**:

- Pollen grains reach the stigma during pollination
- Mature stigma secretes sugary substances
- Pollen grains absorbs the sugary substance & swells
- Exine rupture & intine forms pollen tube through the germ pore
- Normally only one pollen tube arises from pollen grains
- In Althea & Malva many pollen tubes (10 –14) arises from one pollen grains
- The content of Pollen grains enters into the pollen tube cytoplasm is confined towards the apical region
- With in the pollen tube callose plug is formed
  Which restricts the cytoplasm into the apical region
- Tube nucleus is present nearer to the tip & generative cell is present behind the tube nucleus (vegetative cell)
- Prior to the entry of pollen tube into the embryo sac generative cell move towards the tip & vegetative cells lags behind
- Generative cell divides mitotically & forms two male cells/sperm cells

ii) **<u>Entry of Pollen tube into the Ovule</u>**:

- After growing through the style, the pollen tube reaches the ovary & enters the ovule
- Depending upon the region of entry of pollen tube into the ovule, three methods are recognised -----
  a) Porogamy
  b) Chalazogamy
  c) Mesogamy

a) <u>Porogamy</u>: " Entry of Pollen tube into the ovule through micropyle".

- It is the most common method
  Ex: Ottelia

b) <u>Chalazogamy</u>: "Entry of pollen tube into the ovule through chalaza".
Ex: Casurina

c) <u>Mesogamy</u>: "Entry of pollen tube into the ovule either through integuments or funicle Ex: Cucurbita

- The pollen tube enters into the ovule by porogamy, mesogamy or chalazogamy
- Pollen tube enters into the embryo sac only through micropylar end by destroying one of the synergids
- The sperm cells & vegetative cells are released into the embryo sac by small pore formed near the apex of pollen tube

iii) **Fusion of Gametes**: (Double fertilization & triple fusion):

- One of the male cell fuses with the egg & forms diploid zygote. This fusion is called syngamy & was first reported by Strassburger (1884)
- Second male cell fuses with diploid secondary nucleus & forms triploid primary endosperm nucleus (PEN). This fusion involves fusion of three haploid nuclei hence known as Triple fusion
- Triple fusion was first reported by Nawaschin in Lulium & Fritillaria& later found to be universal in all Angiosperms
- In Angiosperms two male gametes fuses with two different cells

i) One male gamete fuses with the egg & forms zygote $\rightarrow$ normal fertilization

ii) Second male gamete fuses with secondary nucleus to form primary endosperm nucleus

- Due to the presence of two fertilizations this phenomenon is known as Double fertilization (Double fertilization = syngamy + triple fusion)
- Primary endosperm nucleus forms endosperm which is nutritive tissue & supplies nourishment to developing embryo

Post fertilization Changes: After fertilization many changes occurs in flowers, which are known as fertilization changes.

- Calyx, corolla, stamens, stigma & style wither away
- Ovary develops into fruit
- Ovules develops into seeds
- Ovary wall develops into pericarp (fruit wall)
- Integuments develops into seed coat
  - testa – outer seed coat
  - tegmen – inner seed coat
- Micropyle of the seed remains as micropyle of the seed
- Zygote endosperm nucleus develops into endosperm
- Zygote develops into embryo
- Synergids & antipodals degenerate
- Funiculus develops into stalk of the seed

Development of Embryo:

- Diploid zygote nucleus secretes a wall around it
- Zygote first divides transversely to produce two cells
- Cell towards micropylar end – basal cell
  Cell towards chalazal end – terminal cell
- Basal cell forms suspensor which pushes the developing embryo into the endosperm
- Terminal cells divides in all planes to produce globular embryo

- Due to growth & differenciation globular embryo develops into mature embryo
- Embryo consists of embryonal axis

Plumule radicle
↓ ↓
Shoot system Root system

- Cotyledons are attached to the embryonal axis
  Dicot embryo $\rightarrow$2 cotyledons
  Monocot embryo $\rightarrow$ cotyledons
- In cereals like maize, rice, wheat, the cotyledous are known as Sculellum
- Plumule is covered by Coleptile & radicle is covered by coleorhiza

<u>Development of Endosperm</u>:

- In angiosperms, endosperms is triploid & formed after fertilization
- In pteridophytes & gymnosperms it is haploid & formed before fertilization
- The triploid endosperm nucleus undergo free nuclear division in the central cell that is followed by wall formation
- The cells organise to form endosperm. It is nutritive tissue which stores food & supplies nutrients to developing embryo
- In some plants during the developmental stages embryo takes food from endosperm & completely utilize it by the time ovule is converted into seed. The ovule contain only embryo. Such seeds are known as exabluminous or nonedospermic seeds.
  Ex: Cicer, Capsella
- In some other plants like Cocos, Ricinus & Datura, the embryo can not utilize
  the endosperm completely. Some amount of endosperm is left out in mature seed.
  Such seeds are known as endospermic seeds or albuminous seeds
- In members of Orchidaceae, Trapaceae endosperm is not formed

<u>Perisperm</u>:

- Embryo sac grows by absorbing the nutrients from the nucellus. Hence nucellus gets depleted when the seed matures
- In the seeds some amount of nucellus is left out which is known as 'Perisperm'
- It is remnent of nucellus & nutritive in function
- Edible part of coffee seeds is perisperm
  Ex: Seeds of Piperaceae (Piper nigrum) & Nympheaceae

<u>Outgrowths of Seeds</u>: Seed of some plants are associated with special outgrowths which may develop from any part of the seed

i) <u>Aril</u>: An integument like circular or annular outgrowth that develops from funicle or hilum of fertilized ovule in aril

- It surrounds the seed completely

Ex: Myristica, Trianthema, Pithecolobium

- Aril of Myristica fragrans is called mace & is used as spice
- Some time aril is considered as thrid integument

ii) Caruncle: Sponge like outgrowth that arises from the integumentary cells at the micropylar end is known as caruncle

- It helps in absorption of water during seed germination
  Ex: Euphoriaceae members

iii) Strophiole: Ex: Fabaceae members

- Fleshy outgrowths developing from hilum

iv) Coma: tuft of hairs present around the seeds. It helps in seed dispersal
Ex: Asclepiadeaceae members

REPRODUCTION

1) All organisms begin their life from
   1) Male gamete 2) Zygote 3) Egg 4) Megaspore
2) The following converts asexual stage into sexual stage in higher plants
   1) Homoetypic division 2) Heterotypic division
   3) Triple fusion 4) Syngamy
3) In angiosperms reproductive organs develop on
   1) condensed stem of sporophyte 2) leaves of sporophyte
   3) stem of gametophyte 4) leaves of gametophyte
4) First cell of endosperm in Gymnosperms is
   1) PEN 2) Microspore 3) Megaspore 4) Secondary Nucleus
5) Last cells of male and female gametophytes in angiosperms respectively are
   1) Microspore, Megaspore 2) Pollen grain, Megaspore
   3) Egg, male gamete 4) Male gamete, egg
6) In angiosperms microsporophyll is equivalent to
   1) Anther 2) Carpel 3) Stamen 4) Ovule
7) Number of locules in mature dithecous anther is
   1) 4 2) 6 3) 8 4) 2
8) The number of layers in anther wall is
   1) 1 – 5 2) 2 – 4 3) 4 – 8 4) 4 – 5
9) Anther wall layer which enriches the sporogenous tissue is
   1) Hygroscopic layer 2) Binucleate layer
   3) Layer with stomium 4) Layer with fibrous thickenings
10) Total number of chromosomes found in a tapetal cell of Nicotiana tabacum is
    1) 48 2) 52 3) 104 4) 96
11) Number of stomata found in each stamen of Crotalaria is
    1) 4 2) 3 3) 2 4) 1
12) Ephemeral layer of anther wall is
    1) 4 2) 3 3) 2 4) 1
13) Older microspores, after their release from, tetrads are referred to as
    1) Oospores 2) Pollen grains 3) Megaspores 4) Zygospores
14) Exine and intine of pollen grain are respectively made up of
    1) Pectin, sporopollenin 2) Sporopollenin, cellulose
    3) Pectin, cellulose 4) Sporopollenin, pectocellulose
15) Pollen grain undergoes the following division

1) Mitosis 2) Meiosis 3) Periclinal 4) 1 & 3

16) Polysiphonous pollen grains and monothecous anthers are found in
1) Malvaceae 2) Cucurbitaceae 3) Asteraceae 4) 1 & 2

17) Number of prothallial cells in the mature male gametophyte of Angiosperms is
1) 2 2) 1 3) 4 4) Absent or zero

18) Total number of cells found in a mature male gametophyte of Angiosperms is
1) 5 2) 3 3) 2 4) 1

19) Movement of pollen tube towards ovule in the Angiosperms is
1) Chemotactic 2) Phototactic
3) Thigmotropic 4) Chemotropic

20) Layer with fibrous thickenings life in between
1) Nutritive layer & Sporogenous tissue
2) Ephemeral layers & Nutritive layer
3) Dikaryotic layer & Ephemeral layer
4) Layer with stomium & Ephemeral layer

21) Connective is absent in the stamens of
1) Tephrosia 2) Allium 3) Hibiscus 4) Tridax

22) During the development of male gametophyte in angiosperms, last mitotic division occurs in
1) Body cell 2) Vegetative cell 3) Generative cell 4) Prothallial cell

23) Integumented megasporangium is called
1) Ovary 2) Ovule 3) Carpel 4) Ovum

24) Megasporangium was first formed in
1) First tracheophytes 2) First land plants
3) Spermatophytes without ovary 4) Spermatophytes with ovary

25) Naked ovules are found in
1) Angiospermic parasites 2) All angiosperms
3) All spermatophytes 4) All gymnosperms

26) Carpel is equivalent to
1) Megasporophyll 2) Microsporophyll 3) Frond 4) Carpophore

27) Nucellus is nacked in
1) Lornathus 2) All gymnosperms 3) Balanophora 4) 1 & 3

28) Generally ovules in Monocotyledonae are
1) Unitegmic 2) Tritegmic 3) Bitegmic 4) Ategmic

29) Distance between micropyle and chalaza is the least in this ovule
1) Alismaceae 2) Brassica 3) Tridax 4) Primula

30) The funicle is long and coils like a watch spring around the ovule in
1) Amiphitropous 2) Anatropous 3) Hemianatropous 4) Circinotropous

31) Both diploid and haploid structures show curvature in this ovule
1) Primula 2) Butamaceae 3) Tridax 4) Polygonum

32) Horse-shoe shaped embroyosac is the feature of this ovule
1) Butamaceae 2) Brassicaceae 3) Primula 4) Opuntia

33) Raphe is formed by a part of
1) Funiculus & chalaza 2) Chalaza & outer integument
3) Outer integument & Funiculus 4) Outer and inner integuments

34) Ovule with raphe is
1) Orthotropous 2) Anatropous 3) Campylotropous 4) Amphitropous

35) Function of parietal cell is
1) Adding cells to female gametophyte
2) Adding cells to endosperm

3) Adding cells to nucellus
4) To produce megaspore mother cell

36) Shape of the tetrad of megaspore is
1) Linear 2) Tetrahedral 3) ‘T’ 4) ‘L’

37) Functional megaspore in Polygonum is found towards
1) Chalaza 2) Micropylar 3) Anterior 4) 1 & 3

38) Megaspore is first described as embryosac when the nuclei are arranged in
1) 2 + 2 2) 3+2+3 3) 3+1+3 4) 4+4

39) Filiform apparatus helps in the absorption of food materials from
1) Endosperm 2) Female gametophyte
3) Nucellus 4) Integuments

40) Diploid structure of female gametophyte is
1) Polar nucleus 2) Secondary nucleus 3) PEN 4) Filiform apparatus

41) Number of embryosac per each ovule is
1) Many 2) 1 3) 2 4) 2 –8

42) The largest cell in the egg apparatus is
1) Central cell 2) Synergids 3) Antipodal 4) Egg cell

43) Ephemeral cells of embryosac are
1) Antipodals 2) Synergids 3) Egg cell 4) Central cell

44) Orthotropous ovule is found in
1) Polygonum 2) Primula 3) Cycas 4) 1 & 3

45) Antithetical process of fertilisation is
1) Heterotypic division 2) Homoetypic division 3) Triple fusion 4) Syngamy

46) The following converts the sexual stage
1) Meiosis 2) Mitosis 3) Triple fusion 4) Fertilisation

47) Identify the incorrect statement
1) Entry of pollen tube into the ovule through micropyle is called porogamy
2) Most common type of entry of pollen tube is chalazogamy
3) Entry of pollen tube into the ovule through chalaza is called chalazogamy
4) Entry of pollen tube into ovule through integuments or funiculus is called mesogamy

48) Chalazogamy was discovered by
1) Strasburger 2) Nawaschin 3) Treub 4) Amici

49) Pollen tube enters the embryosac through
1) Chalaza end2) Micropylar end 3) Antipodals 4) Central cell

50) Triple fusion was first discovered by
1) Strasburger 2) Treub 3) Amici 4) Nawaschin

51) Triple fusion was discovered in
1) Lilium, Alium 2) Lilium, Scilla
3) Fritillaria, Lilium 4) Feronia, Alium

52) Number of genomes involved in double fertilization is
1) 2 2) 5 3) 3 4) 6

53) Number of nuclei participate in triple fusion is
1) 5 2) 2 3) 4 4) 3

54) Style is persistent in
1) Ventilago 2) Naravelia 3) Shorea 4) All the above

55) After fertilization micropyle is useful for
1) Entry of pollentube 2) Seed dispersal
3) Entry of male gametes 4) Entry of water during germination

56) Nutritive tissue useful for developing embryos in Spermatophytes is

1) Nucellus 2) Endosperm 3) Tapetum 4) Endothecium
57) Endosperm of Angiosperms differ from that of Gymnosperms with respect to
1) Ploidy 2) Function 3) Origin 4) 1 & 3
58) Endospermic seeds are found in
1) Solanaceae 2) Liliaceae 3) Fabaceae 4) 1 & 2
59) Ex- albuminous seeds are found in
1) Fabaceae 2) Asteraceae 3) Liliaceae 4) 1 & 2
60) In pulses reserve food is stored in
1) Cotyledons 2) Endosperm 3) Perisperm 4) Nucellus
61) Reserve food in the endosperm of Ricinus and Cocos is
1) Proteins 2) Carbohydrates 3) Oil 4) Organic acids
62) Ploidy of perisperm is
1) n 2) 2n 3) 3n 4) 4n
63) Perispermic and endospermic seed is
1) Piper 2) Cycas 3) Ricinus 4) 1 & 2
64) Edible part of coffee seed is
1) Nucellus 2) Endosperm 3) Perisperm 4) Cotyledons
65) Perispermic seeds are found in
1) Nymphaeaceae 2) Piperaceae 3) Coffea 4) All the above
66) Aerenchymatous aril is found in the seeds of
1) Nelumbo 2) Pithecalobium 3) Myristica 4) Nymphae
67) Spicy aril is found in
1) Pithecalobium 2) Myristica 3) Nymphae 4) Trianthema
68) Sometimes the following out growth of the seed is considered as third integument
1) Aril 2) Caruncle 3) Hairs 4) Wings
69) Aril arises from
1) Hilum 2) Funiculus 3) Micropyle 4) 1 or 2
70) Caruncle is commonly found in
1) Fabaceae 2) Asteracaeae 3) Nymphaeceae 4) Euphorbiaceae
71) Branched ribbon like aril is found in
1) Pithecalobium 2) Nymphaea
3) Embryonic axis 4) Cotyledons
72) In non- endospermic seeds, reserve food is stored in
1) Integuments 2) Seed coat 3) Embryonic axis 4) Cotyledons
73) Caruncle arises from
1) Microphyle 2) Integuments near the micropyle
3) Funiculus 4) Mesocotyl
74) Large cotyledon of cereal seed is called
1) Scutellum 2) Coleorhiza 3) Coleoptile 4) Mesocotyl
75) Multicellular pad like structure found above the radicle is cereals is
1) Colerhiza 2) Coleoptile 3) Mesocotyl 4) Epicotyl
76) Coleoptile is a
1) Protective structure above radicle
2) Large cotyledon
3) Protective structure above the plumule
4) Plumule
77) Ovules in Asteraceae are
1) Unitegmic 2) Anatropous 3) Bitegmic 4) 1 & 2
78) Plant part with more number of meiocytes is
1) Ovule 2) Ovary 3) Anther 4) Bulbil

79) During the development of pollen tube, at first cell present near the tip of pollen tube is
1) Generative 2) Prothallial 3) Antheridial 4) Vegetative
80) Chemical composition of Pollen tube is
1) Sporopollemin 2) Suberin 3) Pectocellulose 4) Pectin
81) Highly reduced and completely parasitic gametophytes are found in
1) Angiosperms 2) Gymnosperms 3) Pteridophyta 4) Bryophyta
82) Gametophytes are dominant in the life cycle of
1) First land plants 2) First true land plants
3) Autotrophic non-embryophytes 4) 1 & 3
83) During germination, pollen tube emerges through
1) Filiform apparatus 2) Spine
3) Germ pore 4) Cap block
84) Unthickened areas in the sporopollenin layer of pollen grain are called
1) pits 2) cap block 3) shot holes 4) germopores
85) In the seeds of Poaceae, reserve food is stored in
1) Endosperm 2) Scutellum
3) Coleoptile 4) Embryonic axis
86) Diploid and triploid nutritive tissues found in the seeds of Piper nigrum respectively is
1) Endosperm, Perisperm 2) Nucellus, Endosperm
3) Perisperm, Endosperm 4) Parietal cell, Endosperm
87) Ploidy of massive and scanty nutritive tissues in the Piper nigrum seed respectively are
1) 2n, 3n 2) 3n, 2n 3) 2n, n 4) 3n, 3n
88) Life cycle in Angiosperms is
1) Diplobiontic 2) Haplodiplontic
3) Diplontic 4) Diplohaplontic
89) Total chromosomes present in colchicine treated zygote of Gossypium is
1) 96 2) 52 3) 104 4) 48
90) Pollen tube was discovered by
1) Amici 2) Nawaaschin 3) Strasburger 4) Benda
91) Study the following and identify the correct match regarding Angiosperms:

List –I	List –II
A) First cell of male gametophyte	I) Megaspore
B) First cell of endosperm	II) Microspore
C) First cell of sporophyte	III) Primary endospermic
D) First cell of female gametophyte	IV) Zygote

A B C D A B C D
1) I III IV II 2) II I IV III
3) II III IV I 4) II IV III I
92) Type of sexual reproduction in Angiosperms is
I) Spore Production II) Oogamy
III) Siphonogamy IV) Zooidogamy
1) II, III 2) II only 3) III only 4) I, II, III, IV
93) Centrifugal arrangement of various layers in anther wall is
A) Endothecium B) Epidermis C) Tapetum D) Middle Layers
1) C D A B 2) B A D C 3) C D B A 4) B A C D
94) Assertion: Endothecium helps in the dehiscence of pollen sac
Reason: At maturity anther dehisces at stomium
1) A and R are true, R is the correct explanation of A
2) A and R are true, R is not the correct explanation of A
3) A is true but R is false

4) A is false but R is true

95) Partly developed male gametophyte of angiosperm consists of
A) Generative cell B) Prothallial cell
B) Vegetative cell D) Male gametes
1) A, B, C 2) A, B 3) A, C 4) A, C, D

96) Number of mitotic divisions required to produce one mature male gametophyte in angiosperms is
1) 2 2) 4 3) 1 4) 3

97) Number of spindle apparatii formed during the development of a mature male gametophyte in Angiosperms is
1) 3 2) 4 3) 2 4) 1

98) Ratio between male gametes and mitotic divisions that occur in a mature male gametophyte of Angiosperms is
1) 2:1 2) 1:2 3) 1:1 4) 2:3

99) Number of meiotic and mitotic divisions required to produce four mature male gametophytes from pollen mother cell in Angiosperms respectively is
1) 1, 8 2) 1, 2 3) 2, 8 4) 4, 8

100) Total spindle apparatii formed during the development of 80 male gametes from pollen mother cells in Angiosperms is
1) 80 2) 110 3) 160 4) 88

Keys

1)2	2)2	3)1	4)3	5)4	6)3	7)4	8)3	9)2	10)4
11)3	12)3	13)2	14)4	15)5	16)1	17)4	18)2	19)4	20)4
21)3	22)3	23)2	24)1	25)4	26)1	27)4	28)3	29)1	30)4
31)2	32)1	33)3	34)2	35)3	36)1	37)1	38)4	39)3	40)2
41)2	42)4	43)1	44)4	45)1	46)4	47)2	48)3	49)2	50)4
51)3	52)2	53)4	54)4	55)4	56)2	57)4	58)4	59)4	60)1
61)3	62)2	63)4	64)3	65)4	66)4	67)2	68)1	69)4	70)4
71)3	72)4	73)2	74)1	75)1	76)3	77)4	78)3	79)4	80)3
81)1	82)4	83)3	84)4	85)1	86)3	87)1	88)4	89)3	90)1
91)3	92)1	93)1	94)2	95)3	96)1	97)3	98)3	99)1	100)2

POLLINATION

Exercise –1

1) Pollination is absent in
1) Spermatophytes 2) Cryptogams 3) Gymnosperms 4) 2 & 3

2) In all the flowering plants, prerequisite for fertilization is
1) Embryo 2) Endosperm 3) Perisperm 4) Pollination

3) In Gymnosperms the pollination is
1) Direct 2) Anemophily 3) Indirect 4) 1 & 2

4) Wind is the only agent for pollination in this group of plants
1) Angiosperms 2) Pteridophytes 3) Gymnosperms 4) 1 & 3

5) Agent for pollination in Angiosperms is
1) Wind 2) Water 3) Animals 4) All the above

6) If self pollination occurs, cross pollination doesn’t occur in
1) Passiflora 2) Dolichos 3) Martynia 4) Orchids

7) Geitonogamy is not possible in

1) Carica 2) Vallisneria 3) Borassus 4) All the above

8) Pollination occured in closed flowers is called
1) Cleistogamy 2) Xenogamy 3) Chasmogamy 4) Dichogamy

9) Autogamy is absent in
1) Gymnosperms 2) Monoecious plants
3) Dioecious plants 4) All the above

10) Investigations of following scientist confirmed that cross pollination has many advantages over self pollination
1) Linnaeus 2) G.Bauhin 3) Francis Darwin 4) Charles Darwin

11) In monoecious and diecious plants, contivance to promote cross pollination is
1) Dicliny 2) Dichogamy 3) Homogamy 4) Herkogamy

12) The following flower is physically bisexual but physiologically unisexual
1) Vallisneria 2) Caltha 3) Scrophularia 4) Cucurbita

13) Third whorl sporophylls mature earlier than that of fourth whorl of the flower in
1) Gossypium 2) Helianthus disc florets 3) Clerodendron 4) All the above

14) Mega spores are formed earlier than microspores in this bisexual flower
1) Colchicum 2) Allium 3) Clerodendron 4) Gossypium

15) Identity the incorrect statement regarding pollination
a. Geitonogamy is not possible in Carica
b. Only Xenogamy is possible in Borassus
c. Autogamy is not possible in Cucurbita
d. Autogamy is possible in Poinsettia

16) Stigmas bend in opposite direction to the stamens in
1) Hibiscus 2) Primula 3) Gloriosa 4) Smilax

17) Herkogamous, homochlamydeous flower belongs to this family
1) Malvaceae 2) Liliaceae 3) Solanaceae 4) Asteraceae

18) Trimorphic flowers and dimorphic stamens are found in
1) Oxalis 2) Primula 3) Brassica 4) Crotalaria

19) Short, long and medium sized styles are found in the flowers of
1) Oxalis 2) Oldenlandia 3) Lythrum 4) 1 & 3

20) Extra floral nectaries and self sterility are found in
1) Passiflora 2) Orchids 3) Abutilon 4) Poinsettia

21) Self sterility occurs with reniform anthers in
1) Passiflora 2) Abutilon 3) Orchids 4) All the above

22) Pollen grains become poisonous on self pollination in
1) Orchids 2) Martynia 3) Passiflora 4) 1 & 3

23) Self pollination may be avoided by closing the stigmas of the flower in
1) Martynia 2) Dolichos 3) Mimulus 4) 1 & 3

24) Geocarpic fruits are formed from Chasmogamous flowers in
1) Archis 2) Streptocarpus princeps 3) Commelina 4) Orchids

25) Cleistogamous flowers and geocarpic fruits are found in
1) Streptocarpus princeps 2) Commelina benghalensis
3) Archis 4) All the above

26) Geocarpic fruits are formed from Cleistogomous flowers in
1) Commelina benghalensis 2) Archis
3) Streptocarpus princeps 4) 1 & 2

27) Symbiotic pollination is exhibited by
1) Orchids 2) Yucca 3) Caltha 4) Argemone

28) Pronuba yuccasella is
1) A Liliaceae member 2) A moth

3) An agent for cross pollination in Yucca 4) 2 &3

29) Agent of pollination in Caltha and Ranunculus is
1) Wind 2) Rain water 3) Insects 4) Birds

30) Wind is the agent of pollination in
1) Artemesia 2) Xanthium 3) Cycas 4) All the above

31) Antithetical contrivance to homogamy is
1) Pollen prepotency 2) Dicliny 3) Self sterility 4) Dichogamy

32) Self pollination occurs through movement of floral parts in
1) Commelina 2) Ranuculus 3) Argemone 4) Ray florets of Tridax

33) The head inflorescence of Helianthus consists of 100 ray and 100 disc florets. If it is covered with a polythene bag before anthesis, how many fruits are produced?
1) No fruit formation 2) 200 3) 100 4) 50

34) Fruits are formed both aerially and inside the soil in
1) Streptocarpus princeps 2) Arachis hypogeal 3) Dolichos
4) Commelina benghalensis

35) Dimorphic flowers and aerial Cleistogamous flowers are found in
1) Commelina benghalensis 2) Amorphophallus
3) Streptocarpous princeps 4) Ceratophyllum

36) In Certophyllum the pollination is
1) Epihydrophily 2) Entomophily 3) Anemophily 4) Hypohydrophily

37) Epihydropily is found in
1) Potamogeton 2) Zostera 3) Vallisneria 4) Isoetes

38) Anemophilous members of largest family in Angiosperms are
1) Artemesia 2) Xanthium 3) Helianthus 4) 1 & 2

39) Versatile stamens are the feature of
1) Entomophily 2) Anemophily 3) Ornithophily 4) Hydrophily

40) It is not an advantage of cross pollination
a. These plants have resistance for diseases
b. In these plants genetic variations are more
c. Productivity of the seed is more
d. The cannot acclilmatize in new environments

41) Single tree cross pollination is called
1) Xenogamy 2) Autogamy 3) Geitonogamy4) Self pollination

42) Genetically self pollination is
1) Xenogamy 2) Geitonogamy3) Autogamy 4) Cleistogamy

43) Xeonogamy is
1) Genetically self pollination 2) True cross pollination
3) Cross pollination occurs between two plants of the same species 4) 2 & 3

44) First agent in pollination is
1) Water 2) Insects 3) Birds 4) Wind

45) Contrivance which ensures 100% cross pollination is
1) Pollen prepotency 2) Protandry 3) Herkogamy 4) Dicliny

46) Cent per cent self pollination is ensured by
1) Homogamy 2) Clestogamy 3) Sensitive stigmas 4) Pollen prepotency

47) Identify the incorrect statements regarding Primula
a. Long and short styles are found in the dimorphic flowers of a plant
b. Stamens are arranged in two different heights in a flower
c. Both types of flowers show herkogamy
d. Dichogamy, herkogamy and diheterostyly are found

48) Autogamy occurs ins this Fabaceae member
1) Lathyrus 2) Pisum 3) Dolichos 4) 1 & 2

49) Mechanism of pollination Fabaceae is
1) Pit- fall 2) Piston 3) Pollinia 4) Lever

50) Self pollination occurs in this Solanaceae member
1) Tobacco 2) Tomato 3) Brinjal 4) Sun berry

51) Assertion: In Gymnosperms the pollination is direct
Reason: In Gymnosperms pollen grains fall directly on the micropyle of ovule
a. A and R are true, R is the correct explanation of A
b. A and R are true, R is not the correct explanation of A
c. A is true but R is false
d. A is false but R is true

52) Assertion: Pollination is direct in all Angiosperms
Reason: Pollen grains fall on the stigma in all Angiosperms
a. A and R are true, R is the correct explanation of A
b. A and R are true, R is not the correct explanation of A
c. A is true but R is false
d. A is false but R is true

53) Autogamy is absent in
A) Unisexual flowers B) Bisexual flowers
C) Flowers on monoecious plants D) Flowers on dioecious plants
1) Except B 2) A only 3) C, D only 4) ABCD

54) Study the following and identify the correct match

Pollination	Agent
A) Ornithophily	I) Wind
B) Hydrophily	II) Animals
C) Zoophily	III) Water
D) Anemophily	IV) Birds

	A	B	C	D
1)	IV	III	II	I
2)	IV	III	I	II
3)	III	II	I	IV
4)	III	IV	II	I

55) Type of pollination occurs in dioecious plants is
A) Autogamy B) Geitonogamy C) Xenogamy
1) A, B 2) A, C 3) B, C 4) C only

Keys Ex –1

1)2	2)4	3)4	4)3	5)4	6)4	7)4	8)1	9)4
10)4	11)1	12)3	13)4	14)1	15)4	16)3	17)2	18)1
19)4	20)1	21)2	22)1	23)4	24)1	25)2	26)1	27)2
28)4	29)2	30)4	31)4	32)3	33)3	34)4	35)3	36)4
37)3	38)4	39)2	40)4	41)3	42)2	43)4	44)4	45)4
46)2	47)2	48)4	49)2	50)1	51)1	52)1	53)1	54)1
55)4								

UNIT -IV
PLANT SYSTEMATICS

- "Branch of Botany that deal with Identification Nomenclature & Classification is known as Plant Taxonomy" (Systematic Botany)
- It is derived from Greek word
  Taxis = arrangement
  nomos = law or rule
- Word 'Taxonomy' was coined by A.P. *d*e Candolle (1813)
- Taxonomy plays an important rule in study of all other branches of Botany like anatomy, morphology, embryology, cytology, palynology, ecology etc
- Nature consists of 4,00,000 kinds of plants which constitute plant kingdom
- Phanerogams constitute dominant flora consisting of about 2, 87,000species They show diversity in their habitat, habit, nutrition, life span, methods of reproduction etc. It is impossible to remember the characters of each plant hence grouping is essential to understand plant world.
- Plant Taxonomy is very old science. Primitive man grouped plants into useful, unuseful & Poisonous plants
- Aristotle, Plato & Theophrastus classified plants into herbs, shrubs & trees
- Parasara identified several medicinal plants & recorded them in his book 'Vrikshayurveda' He is regarded as " Father of Botany in India"
- On the basis of medicinal properties & ecological association Charaka classified plant kingdom into 50 groups
- Taxonomy purely based on morphological characters is known as 'Alpha axonomy'
- Taxonomy based on information collected from morphology, embryology, cytology, palynology, photochemistry etc is known as 'Omega Taxonomy'
- In Omega Taxonomy more importance is given to phylogeny

Objectives of Taxonomy:

i) To identify & describe world flora
ii) To provide suitable method for identification of plants
iii) To collect & preserve plants in herbaria
iv) To provide phylogenetic & universal classification
v) To study relationship among different taxa

Aspects of Taxonomy: Three important aspects of Taxonomy are ----

a) Identification b) Nomenclature c) Classification

Identification:

- It is prerequisite for classification
- It is made with the help of floras & herbarium
- Determining whether a collected plant is entirely new or already known is known as identification
- Proper identification of plants is essential for taxonomic studies. It is carried out by BSI
- Modern method of identification is use of computer punch card keys
- Royal Botanical Garden at Kew, England has largest herbarium
- Term herbarium was coined by Linnaeus

Nomenclature:

- System of naming of plants on scientific basis is known as nomenclature

- Plants growing in particular area are named in language spoken in that area. Such names are known as vernacular names or common names
- Vernacular names cause great confusion as a single plant may have several names in various localities & languages
  Ex: Hibiscus rosa –sinenses have two common names in Teluge as Mandara & Dasani. Such situation leads to confusion
- To avoid such confusions, universally accepted names should be used. The names should be in Latin

Binomial Nomenclature:

- In earlier days several latin words were used to name a plant. Such naming is known as polynomial nomenclature
- Gasperd Bauhin (1623) introduced Binomial Nomenclature. He used only two latin words
- Rivinus (1690) proposed that name of any plant should not have more than two words
- Linnaeus (1753) is more familiar with binomial nomenclature as He strictly followed binomial system in his book "Species Plantarum" & known as "Father of Taxonomy"
- According to binomial system, name of plant consists of two words in latin
- First word →Generic name (Genus)
  Second word →Specific name (Species)
- Generic name is noun & starts with capital letter where as specific name is adjective & starts with small letter
- Specific name is followed name of author who described it first
  Ex: Mangifera indica Linn

International Code of Botanical Nomenclature: (**ICBN**)

Name of all plants should be according to the principle laid down by ICBN

- International Botanical Research meetings formulated Paris Code (which are held once in 5 or 10 years)
- Meeting held at Tokyo in 1994 formulated Tokyo code
- According to ICBN

i) Every plant should have one correct name
ii) Name of plant should follow binomial system
iii) Scientific names must be in Latin or Latinised from of English
iv) Scientific, name should be underlined or published in italics
v) Author's name should be given in abbreviated form at the end of Scientific name
vi) When specific name consists of two words hyphen should be used between the names
Ex: Hibiscus rosa – sinensis Dolicos lab – lab
vii) If generic & specific names are same it is known as tautonymy & such names are known as tautonyms
Ex: Raffia rafia, Malus malus

- According to ICBN tautonyms are not valid in plant nomenclature

Classification: Grouping of plants on the basis of similarities & dissimilarities is known as classification

- Linnaeus proposed specific principles of classification which were refined in the course of time

- Vegetative characters are not stable as they undergo change according to environmental conditions
- Floral characters shows variations & stability & hence they are more reliable or useful in classification
- Classification should reflect evolutionary trends also
- Evolutionary trends in morphological characters are ----

Primitive Characters	Advanced Character
1) Perennials	1) Annuals & Biennials
2) Trees & Shrubs	2) Herbs
3) Simple leaves	3) Compound leaves
4) Solitary flowers	4) Inflorescence
5) Actinomorphic flowers	5) Zygomorphic flowers
6) Bisexual flowers	6) Unisexual flowers
7) Monoecious condition	7) Dioecious conditions
8) Polysepalous & Polypetalous condition	8) Gamopetalous & Gamosepalous condition
9) Dichlamydous	9) Monochlamydous & Achlamydous flowers
10) Hypogynous flower, superior ovary	10) Epigynous flower, inferior ovary
11) Carpels free	11) Carpels fused
12) Simple fruit	12) Multiple fruits
13) Seeds with large endosperm	13) Seeds with scanty endosperm

<u>Units of Classification</u>:

- ICBN provides a list of units in classification of plants
- Units of classification are known as taxon
- Kingdom is highest unit & species is the basic unit of classification
- Sequence of units of different ranks are ----
  Kingdom, division, sub – division, class, sub –class, series, order family, genus & species
- A group of genera which shows structural similarities mainly in their floral oranges is called as tribe
- A group of freely inter breeding plants is defined as species
- A group of closely related species is known as genus
- Different genera with comman characters are grouped into family
  Ex: Arachis, Pisum, Dolichos, Phaseolus are placed in fabaceae
- According to ICBN family name always ends with ‘aceae’
- Closely related families are grouped into order
  Ex: Fabaceae, Caesalpinaceae & Mimosae are placed in Rosales
- Order name ends with ‘ales’
- Group of related orders are placed in series
- Group of related series are considered as class
- Different classes with similar characters are grouped into division
- Group of divisions constitute kingdom

Types of Classification:

- Based on different criteria, several taxonomists proposed different systems of classifications
- All the systems can be grouped into three types -----
  i) Artificial systems
  ii) Natural systems
  iii) Phylogenetic system

i) Artificial system: Classification based on one or few easily comparable morphological characters is known as artificial system of classification

- 1st artificial system was proposed by Theophrastus in his book 'Historia Plantarum'. He classified plants on the basis of habit into herbs, shrubs & trees
- Linnaeus proposed sexual system of classification on the basis of floral characters. He classified plants into 24 classes

ii) Natural System of Classification: Classification based on several morphological characters is known as natural system of classification.

- 1st natural system was introduced by de Jussieu
- Most famous urdely accepted natural system was proposed by Benthan & Hooker

iii) Phylogenetic System of Classification: Classification based on origin & evolutionary tendencies of plant is known as phylogenetic system.

- It was proposed after Dawin's theory of evolution hence also known as Post-Darwinian classification
- It reflects the genetic & evolutionary relationship among taxa
- This system is shown in the form of phytogentic system
- 1st phylogenetic system was proposed by Eichler
- Most popular phylogenetic system was proposed by Engler & Prantle

Bentham & Hooker's System of Classification:

- Most popular 'Natural system' of classification was proposed by British taxonomists George Bentham & Dalton Hooker
- They published natural system in three volumes of Genera Plantarum
- Benthan & Hooker's classification was based on system proposed by de Candolle
- They described 97.205species & grouped them into 202 natural orders i.e. families
- 165 families belong to dicotyledonae, 3 belong to gymnospermae & 34 belong to monocotyledonae
- Bentham & Hooker divided Phanerogams into Dicotyledonae, Gymnospemae & Monocotyledonae

Class: Dicotyledonae: It is characterised by the presence of ----
i) tap root system
ii) reticulate venation
iii) tetramerous or pentamerous flowers
iv) two cotyledons in seed

- On the basis of number & nature of perianth, Dicotyledonae is further divided into three sub – classes
  a) Polypetalae
  b) Gamopetalae
  c) Monochlamydae

Sub –Class Polypetalae:
i) Perianth is distinct, differenciated into calyx & corolla
ii) Petals are free

- On the basis of nature of Thalamus & position of ovary with respect to other floral parts, Polypetalae is further divided into three series ----
  i) Thalamiflorae
  ii) Disciflorae
  iii) Calyciflorae

Series: Thalamiflorae:
- Thalamus is elongated, conical or convex
- Hypogynous flowers with superior ovary
- It includes 6 orders Ex: Ranales, Parietals, Malvales etc
- Malvaceae family belongs to Malvales

Series: Disciflorae:
- Hypogynous flowers with superior ovary
- Cushion like disc is present beneath the ovary
- It includes 4 orders
  Ex: Geranials, Olacales, Celatrales & Sapindales

Series: Calyciflorae:
- Perianth is distinct & is differenciated into Calyx & Corolla
- Gamopetalous corolla (petals fused)
- Epipetalous stamens
- Based on nature of ovary & merosity of flower, Gamopetalae is divided into 3 series----
  i) Inferae ii) Heteromerae iii) Bicarpellatae

Series: Inferae:
- Epigenous flower, inferior ovary
- It includes 3 orders Ex: Rubiales
- Asterales, Companulales
- Asterales includes Asteraceae family

Series: Heteromerae:
- Ovary superior, bicarpellary or multicarpellary
- Stamens equal to number of petals or double the number of petals
- It includes 3 orders Ex: Ericalers, Primulales & Ebenales

Series: Bicarpellatae:
- Bicarpellary, superior ovary
- Some times stamens are less (in number) than petals
- It includes 4 orders Ex: Genteales, Polemoniales, Personales & Lameales
- Solanaceae family is included in Polemoniales

Sub –Class: Monochlamydae:
- Perianth in one whorl & is not distinct
- Perianth is sepaloid
- It includes 8 series Ex: Cruvembrae, Ordines anamoli etc
- It is not divided into orders
- Families are included under each series

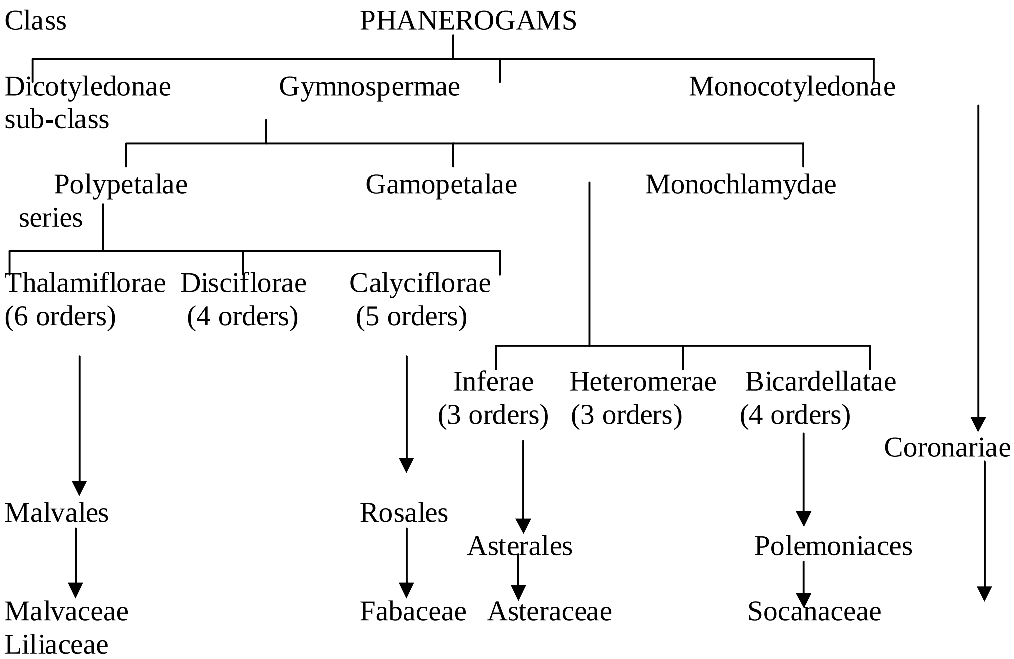
Class: Gymnospermae: It is placed between Dicotyledonae & Monocotyledonae
- It includes plants with naked ovules
- It includes 3 families Ex: Cycadaceae, Comferaceae, Gnetaceae

Class: Monocotyledonae: It is characterised by the presence of ----
i) adventitious root system

ii) parallel venation
iii) trimerous flower
iv)One cotyledon is seed

- On the basis of nature of perianth & condition of ovary, it is divided into 7 series. Ex: Microspermae, Epigynae, Coronariae, Glumaceae
- Series is not divided into orders
- Families are directly placed in the series
- Liliacaeae is included under Coronariae

<u>Benthem & Hookers system of Classification</u>:



FABACEAE

Sub division – Angiospereae
Class – Dicotyledonae
Sub class – Polypetalae
Series – Calyciflorae
Order – Rosales
Family – Fabaceae

- Sub family Papilionoideae of the family Leguminosae is now considered as separate family
- Fabaceae includes 452 genera & 7200 species
- The members of this family are cosmopolitan mostly confined to tropical & sub –tropical regions

<u>Important Plants</u>: <u>Examples</u>

1) Crotolaria juncea – Sun hemp
2) Cajanas cajan – Red gram/Pigeon pea
3) Phaseolus mungo – Black gram

4) Cicer arietinum – Bengal gram
5) Arachis hypogea – Ground nut
6) Dolichos lab- lab – Bean
7) Pisum sativum – Garden pea
8) Lathyrus sativus – Wild pea
9) Dalbergia latifolia – Indian Rose wood
10) Pterocarpus santalinus – Red sandalwood
11) Glycine max – Soya bean
12) Indagofera tinctoria – Blue dye plant
13) Tephosia purpura – Vempali
14) Abrus precatorius – Crab's eye; Goldsmith's weight
15) Butea monosperma(Butea frondosa) – Flame of forest

Habitat:

- Mostly plants are mesophytes
- Rarely Xerophytes Ex: Ulex

Habit:

- Plant are mostly annual herbs Ex: Arachis, Pisum
- Some are Shrubs Ex: Crotolaria, Cajanus
- Some are trees Ex: Pongamia, Dalbergia, Pterocarpus
- Tendril climbers Ex: Pisum, Lathyrus
- Twinners Ex: Dolichos, Clitoria

Root System:

- Tap root system with bacterial nodules, hence also known as nodular roots
- Rood nodules contain nitrogen fixing symbiotic bacteria called Rhizobium
- Nodules also contain leg- hemoglobin (purple (or) pink pigment)

Stem:

- Aerial, erect, herbaceous or woody
- In some plant it is weak & prostrate Ex: Heylandia
- May be twinner Ex: Dolichos, Abrus
- May be climber Ex: Pisum, Lathyrus

Leaves:

- Cauline, petiolate & stipulate leaves
- Leaves may be simple Ex: Crotolaria juncea
- Leaves may be pinnate compound Ex: Pisum, Abrus
- Leaves may be palmate compound Ex: Dolichos, Phaseolus
- Leaf base is pulvinous & hence leaves shows sleeping (nyctinastic) movements
- In Lathyrus & Pisum stipules are modified into foliaceous stipus helps in photosynthesis
- Terminal leaflet are modified into tendrils which helps in climbing; in Ulex – leaflet modify into spines
- Leaves shows reticulate venation & alternate phyllotaxy

Inflorescence:

- Plants shows racemose infloresence
- Flowers in dense head Ex: Phaseolus
- Inflorescence may be simple raceme (Crotalaria) Panicle (Dalbergia)
- It may be axillary or terminal

Flower in General:

- Flowers are pedicellate, bracteate & bracteolate
- Flowers are complete, bisexual, zygomorphic, pentamerous, dichlamydous & heterochlamydous, perigynous & show cyclic arrangement

Flower in Detail:

Calyx:
- Sepals are 5, gamosepalous
- Sepals shows valvate aestivation
- Odd sepal is anterior in position

Corolla:
- Petals 5, Polypetalous, paplionaceous & shows descending imbricate aestivation
- Odd petal posterior in position
- Odd petal ---- standard petal or Vexillum
- Lateral petals – wings or alae
- Two anterior petals – keel petals or Carina
- Keel petals encloses essential organs

Androecium:
- Stamens are 10, arranged in one or two bundles
- Monoadelphous in Arachis, Crotalaria
- Diadelphous in Tephrosia, Dolichos, Pisum
- Anthers are dithecous, basifixsed & introse
- Staminal tube is free at one margin

Gynoecium:
- Monocarpellary, unilocular, half superior or superior ovary, ovules arranged on marginal placentation
- Nectar glands at the base of ovary
- Style terminal, simple and curved
- Stigma capilate or hairy

↑
- Floral formulae: Br Br*l*% O $\underset{+}{K_{(5)}}$ $C_{1+2+(2)}$ A_{10} $\underline{G}_{1}$

Pollination: Self pollination in Pisum & Lathyrus
- Mostly cross pollination, Protandrous flowers, entomophily
- Pollination by birds in Erythrina indica
- Cross pollination by piston mechanism
- Insects are attracted by Standard petal, land on wing petal & press them in search of nectar
- Keel petals also pressed down & open exposing stigma & stamens
- Stigma comes out first & touch the abdomen of insect & receive pollen grains
- When anther comes in contact with insect body, the pollen is deposited on the body
- When the insect leaves the flower, essential organs comes to their original position
- Movement of essential organs is like that of piston, hence known as piston mechanism

Fruit:
- Legume or pod is most of the plants
- In Arachis, fruit is geocarpic (under ground) & indehiscent pod
- Samara in Pterocarpus & Dalbergia

Seeds:
- Seeds are non – endospermic
- Embryo is large & dicotyledonous
- Cotyledous are rich in proteins

Economic Importance:
- Cajanus, Phaseolus, Cicer etc are used as Pulses. They are rich in Proteins
- Fruits of Dolichos, Pisum, Glycine max etc are used as vegetables
- Seeds of A.hypogea yields ground nut oil; Seeds of Glycine maxs yields soya bean oil. These oils are used in cooking
- The oil cake of A.hypogea is used as fodder
- Goldsmiths use the seeds of Abrus precatorius for weighing gold
- C.juncea & P.trilobus are used as fodder crop
- Due to nitrogen fixing ability, several crops are used in crop rotation
- Seeds of Trigonella (methi) are used as condiment & medicine. Leaves are used as vegetables
- Indigofera tinctoria yields blue dye
- Sesbania & Tephrosia are used as green manure
- Wood from Pterocarpus santalinus (Red Sanders) is used for making musical instruments
- Wood from Dalbergia latifolia (Rose wood) is used in making furniture
- The oil from seeds of Derris elliplica is used in medicines
- Fibre from C.juncea (Sun hemp) is used in making ropes

SOLANACEAE

Class – Dicotyledonae
Sub class – Gamopetalae
Series – Bicarpellatae
Order – Polemoniales
Family – Solanceae

Important Examples:
1. Lycopersicon esculentum – Tomato
2. Solanum melongena – Brinjal
3. Solanum tuberosum – Potato
4. Nicotiana tabacum – Tobacco
5. Capscicum fruitescens – Chillies
6. Petunia alba – Petunia
7. Cestrum nocturnum – Night queen
8. Cestrum diurnum – Day king
9. Datura metal – Datura/ Thorn apple
10. Solanum nigrum – Kamanchi
11. Withania somifera – Aswagandha
12. Physalis peruviana – Gooseberry
13. Atropa belladona – Belladona
14. S. xanthocarpum (S.surratens) – Vaakudu

Occurance & Distribution:
- Plants are mostly distributed in tropical regions
- Chiefly found in Central America & South America

- Family is represented by 85 genera & 2200 species

Vegetative Characters:

Habitat:

- Plants are mostly mesophytes
- Some plants are Xerophytes (ephemeral) Ex: Solanum xanthocarpus

Habit:

- Plants are mostly annual or perennial herbs (Petunia, Solanum)
- Some Plants are shrubs Ex: Cestrum
- Rarely small trees are also found Ex: S. verbascifrlium

Root system:

- Tap root system

Stem:

- In S.surattense stem is weak & climbs with the help of prickles
- Aerial, erect & herbaceous
- Stem is covered either by hairs or prickles
- Stem tubers are seen in Solanum tuberosum
- Petioles & peduncles commonly shows adriation with stem
- Bicollateral vascular bundles are seen in stem (Phloem is present on either side of xylem & is separated by cambium)

Leaves:

- Petiolate, exstepulate & simple leaves
- Leaves are simple or pinnately L.esculuntum lobed
- Leaves are Obligue, shows dentate margin & acute tip
- Venation is reticulate
- Alternate phyllotaxy is vegative region but becomes opposite or whorled in flowering region due to adnation of petioles

Floral Characters:

Inflorescence:

- In most of the plants cymose inflorescence is seen
- In Nocotiana & Withiana – Panicle
- It may be axillary or terminal in position
- Solitary axillary in Solanum, Physalis
  Solitary terminal in Datura
- In some species of Solanum it is Scoropoid cyme & appears to be arising extraaxillary due to adnation of peduncle with internode

Flower in General:

- Flowers are pedicellate bracteate or ebracteate, ebracteolate
- Flowers are complete, bisexual, pentamerous actinomarphic or obliguely zygomorphic, hypogynous & cyclic

Flower in Detail:

Calyx:

- Sepals 5, gamosepalous, tubular
- Aestivation in valvate
- Calyx is persistant in Solanum, Capsicum & Physalis

Corolla:

- Petals 5, gamopetalous with twisted or valvate aestivation

- Corolla may be infundibulliform (funnel shaped) in Datura; tubular in Cestrum or rotate in Solanum, Campanutate (bell shaped)– Atropa, Physalis

Androecium:

- It consists of 5 stamens
- Stamens are epipetalous & alternates with petals
- Anthers are dithecous, basifixed & introse
- Dehiscence may be longitudinal (Datura) or Porous (Solanum)

Gynoecium:

- It consists of bicarpellary, bilocular, syncarpous superior ovary
- In Datura ovary becomes tetralocular due to the formation of false septum
- Ovary is unilocular due to clockwise rotation (torsion) by 45^0
- Placenta is swollen
- Ovules are arranged on axile placentation
- Style is long & terminal
- Stigma is capitate or slightly bilobed.

Floral Formula:

Br EBrl $\underset{+}{\overset{\uparrow}{O}}$ $K_{(5)}$ $\widehat{C_{(5)}\ A_{(5)}}$ $\underline{G}_{(2)}$

Pollination: flowers are attractive & scented

- Most of plants shows cross pollination
- It is entomophilous cross pollination
- Flowers are usually protandrous
- Some species of Solanum are protogynous
- Self pollination occurs in Nicotiana

Fruit:

- It is mostly berry Ex: Solanum, Capsicum, Lycopersicon etc
- It is septifragal capsule in Datura & Nicotiana

Seed:

- Seeds are endospermic with dicotyledonous embryo
- Embryos are generally curved but it is straight in Nicotiana

Economic Importance:

- Fruits of Solanum melongena, Lycopersicum esculentum & stem tubers of Solanum tuberosum are used as vegetables
- Ripe fruits of Solanum nigrum, Lycopersicum & Physalis are edible
- Capsicum fruitesence contain an alkaloid 'Caspine'
  The powder of dry fruits is used as Condiment in preparation of pickels & cooking
- Atropa belladona contains atropine & is useful in making plasters
- Datura, Atropa, Withania, S.Xanthocarpus are medicinal plants
- Leaves of Solanum surattense & Datura stramonium are useful for curing asthma
- Species of Cestrum & Petunia are Ornamental plants
- Nicotiana tobaccum is a commercial crop. The leaves contain 'nicotine' & are used to prepare cigar, cigarates etc
- Root extract of Withania somnifera is used as a rejuvenating tonic

LILIACEAE

Class – Monocotyledonae

Series – Coronariae
Family – Liliaceae

Important Examples:
1. Allium cepa – Onion
2. Allium sativum – Garlic
3. Asparagus racemosus – Asparagus, Sathamuls
4. Colchicum autumnale – Meadow saffron
5. Gloriosa superba – Morning glory, Glory lily
6. Lilium candidum – Lily
7. Ruscus aculeate – Butcher's broom
8. Yucca gloriosa – Spanis dagger /Adams needle
9. Smilax zeylanica – Sarsaparilla
10. Aloe barbadensis – Sarsaparilla
11. Dranaina angustifolia
12. Scilla hyacinthiana

Occurance & Distribution:
- Plants are cosmopolitan in distribution, majority of them are found in tropical regions
- Liliaceae family is represented by 254 genera & 4075 species

Vegetative characters:

Habitat:
- Members of this family are represent by both mesophytes & Xerophytes
- Mesophytes Ex: Allium, Lilium, ScillaXerophytes Ex: Asparagus, Ruscus, Aloe
- Xerophytes Ex: Asparagus, Ruscus, Aloe

Habit:
- Plants are mostly perennial herb
- Some plants are shrubs or trees Ex: Yucca, Dracena
- Few plants are climbers Ex: Smilax, Gloriosa, Asparaoys

Root System:
- Adventitious / fibrous root system
- Fasciculated tuberous roots are seen in Asparagus

Stem:
- In most of the species perennating underground stem is seen. It may be bulb, rhizome or corm
- Rhizomatous stem Ex: Gloriosa
  Corm Ex: Colchicum
  Bulb Ex: Allium, Scilla, Lilum naked, erect scaly
- Aerial stems are weak,
- It may be tendril climbers Ex: Smilax, Gloriosa
- Stem is arborescent (woody) Ex: Yucca, Dracaena
- In Asparagus & Ruscus branches are modified to cladodes
- Vegetative reproduction is by bulbil Ex: Lilium- bulbiferum or by suckers Ex: Aloe

Leaf: Leaves may be ----
- radical Ex: Allium, Lilium
  cauline Ex: Smilax, Gloriosa

- Leaves may be small or petiolate & simple
- Leaves may be succulent Ex: Yucca, Aloe
- Succulent leaf bases seen in Allium cepa, Scilla
- Fleshy scale leaves are seen in A.sativum, Lilium
- Leaves are reduced to scales Ex: Asparagus, Ruscus
- Stipules in smilax & leaf apex in Gloriosa are modified to tendrils
- In Scilla, leaf apex bears epiphyllous buds which helps in vegetative reproduction
- Parallel venation in most of the plants but reticulate venation is seen in Gloriosa, Smilax

Floral Characters:

Inflorescence:

- Members of Liliaceae shows various types of racemose inflorescence
- It may be axillary (Lilium) or terminal (Gloriosa)
  Simple raceme in Asparagus
  Panicle in Yucca, Aloe
  Umbel in Allium, Smilax. Long, stalk like
  Peduncle that arises from the underground stem is known as 'Scape'.

Flower in General:

- Flowers are usually pedicellate, bracteate & ebracteolate
- They are trimerous, complete, bisexual, actinomorphic homochlamydous dichlamydous & hypogynous
- Flowers are unisexual in Smilax & Ruscus
- Perianth not differenciated into calyx & Corolla (Homochlamydous)

Flower In Detail:

Perianth:

- It is not differenciated
- It consists of 6 tepals arranged in two whorls of 3 each
- Perianth may be polyphyllous (Lilium) or gamophyllous (Aloe) & are petaloid
- Aestivation in valvate or imbricate

Androecium:

- Stamens are six, arranged in two whorls
- They are free or epiphyllous
- Anthers are dithecous, basifixed
  introse & shows longitudinal dehiscence

Gynoecium:

- It consists of tricarpellary, trilocular, syncarpous superior ovary
- Ovules develops on axile placentation
- Style is terminal stigma is trifid & capitate
- Ovary has Septal nectaries

Floral Formula:

$$Br.\ EBrl \oplus O\ P_{3+3}\ A_{3+3}\ \underline{G}_{(3)}$$

Pollination:

- Usually cross pollination; entomophyllous type
- Insects are attracted by nectaries

- Symbiotic type of pollination is seen in Yucca
  It is carried out by a moth Pronaba yuccasella
- Protandry is seen in Allium
- Herkogamy is seen in Gloriosa

Fruit:
- Seeds are endospermic with straight or curved embryo
- Polyembryony is seen in some members Ex: Allium

Economic Importance:
- Bulbs of Allium cepa are edible & have bacterial properties
- Cloves of Allium sativum are used as spice. It is a good medicine for gastric & heart problems.
- Tuberous roots of Asparagus are edible
- 'Sarasaparilla' is a medicine obtained from the roots of Smilax
- Leaves of Yucca & Dracaena yields fibre
- Colchicine is obtained from the corms of Colchicum autumnale
- Gloriosa, Lilium, Asparagus, Tulipa are grown as ornamental plant

TAXONOMY

Exercise –1

1) 'Sarasaparilla' is a medicine obtained from these parts of Smilax
   1) Stem 2) Leaf 3) Root 4) Flower
2) A Liliaceae member which propagates by means of suckers is
   1) Gloriosa 2) Aloe 3) Yucca 4) Dracaena
3) Ray florets in Asteraceae consists of
   1) Bisexual, actinomorphic, epigynous flowers, whose sepals are modified into pappus
   2) Bisexual zygomorphic, hypogonous flowers, whose sepals are not modified
   3) Unisexual, female, zygomorphic, epigynous flowers, whose sepals are modified into pappus
   4) Unisexual, female, actinomorphic, hypogynous flowers, whose sepals are not modified
4) Seeds are Medicinally important and leafy vegetable plant of Fabaceae is
   1) Crotalaria 2) Trigonella 3) Tephrosia 4) Abrus
5) The flower of Crotalaria is zygomorphic due to
   1) Calyx 2) Corolla 3) Androecium 4) Gynoecium
6) The plant whose seeds yield sunflower oil and the petals give pink colour dye is
   1) Calendula officinalis 2) Helianthus annus
   3) Rauwolfia serpentina 4) Carthamus tinctoruis
7) One of the following statement is wrong about Solanaceae
   1) Adnation 2) Swollen axile placentation
   3) Bicarpellary, superior ovary 4) Monocarpellary, superior ovary
8) Wood of the following plant is useful in making musical instruments
   1) Dalbergia latifolia 2) Santalum album
   3) Pterocarpus santalinus 4) Hardwickia binata
9) The total number of stamens is ten. But they are present in only one bundle in this member of Fabaceae

1) Dolichos 2) Pisum 3) Arachis 4) Tephrosia

10) Hood that is present on the stamen of Asteraceae members is
1) Sterile part of anther 2) Extended part of connective
3) Extended part of filament 4) Extended part of anther lobe

11) Pollinating agent is wind in a member of Asteraceae, which shows zoochory and that plant is
1) Artemisia 2) Xanthium 3) Tridax 4) Tagetus

12) The ovary of Solanaceae tilts at an angle of
1) 90^0 2) 45^0 3) 145^0 4) 15^0

13) Self pollination is prevented by the following contrivance in a Liliaceae plant that has septicidal capsule
1) Self sterility 2) Dicliny 3) Herkogamy 4) Triheterostyly

14) National and International centre for plant identification respectively is
1) BSI, Royal Botanical gardens 2) FRI, Indian botanical garden
3) Lucknow, Kew 4) Historia plantarum, BSI

15) Floral characters were given importance in classification for the first time by
1) De Jussieu 2) Linnaeus 3) Bentham and Hooker 4) Eicher

16) Total number of cohorts in gamopetalae of Bentham and Hooker's classification is
1) 25 2) 15 3) 10 4) 21

17) In Bentham and Hooker's classification, class without cohorts is
1) Monocotyledonate 2) Monochlamydae
3) Dicotyledonate 4) Both 1 & 2

18) A fibre yielding fodder crop of Fabaceae is
1) Hibiscus cannabinus 2) Crotalaria juncea
3) Sesbania sesban 4) Phaseolus

19) The old name of Fabaceae is based on the character of
1) Calyx2) Corolla 3) Androecium 4) Placentation

20) In Bentham and Hooker's classification Papilionoideae was classified as
1) Natural order 2) Cohort 3) Sub family 4) Family

21) The rules of nomenclature are formed by
1) International Botanical congress 2) ICBN
3) Royal Botanic Garden 4) Index kewensis

22) Free stamen of Tephrosia flower is
1) Anterior 2) Posterior 3) Anterolateral 4) Posteriolateral

23) Pollen and fruits –both are dispersed by wind in
1) Xanthium 2) Zinnia 3) Tridax 4) Artemisia

24) This plant is used as a leafy vegetable and has also medicinal value
1) Lactuca sativa 2) Hibiscus cannabinus
3) Derris elliptica 4) Trigonella foenum – graecum

25) In the vascular bundle of stem of the following plant xylem tissue is sandwitched between two patches of living conducting tissue
1) Thorn apple 2) Spanish dagger 3) Belladona 4) 1 & 3

26) Fruits of a Solanaceae member are edible and are of great medicinal value
1) Vaakudu 2) Kamanchi 3) Aswagandha 4) Belladona

27) Chlamydeous, incomplete flowers are present in
1) Smilax, Asparagus 2) Smilax, Ruscus
3) Ruscus, Allium 4) Smilax, Yucca

28) Aerial weak stem and underground rhizome is found in

1) Scilla 2) Smilax 3) Ruscus 4) Gloriosa

29) Roots are useful in
1) Cichorium, Asparagus, Allium 2) Asparagus, Withania, Smilax
3) Asparagus, Withania, Artemesia 4) Cnichorium, Asparagus, Scilla

30) Economic importance of shrub of Solanaceae is
1) Ornamental plant 2) Leafy vegetable
3) Medicinal plant 4) Fodder crop

31) K_0 is found in this floral formula
1) Malvaviscus 2) Helianthus
3) Xanthium 4) Capsicum

32) Type of inflorescence in the nomenclature type of genus of compositae is
1) Compound head
2) Homogamous head with all ray florets
3) Homogamous head with all disc florets
4) Heterogamous head

33) Number of cohorts is same in
1) Thalamiflorae and Bicarpellatae
2) Inferae and Disciflorae
3) Disciflorae and Bicarpellatae
4) Heteromerae and Disciflorae

34) One seeded dry indehesicent fruit is found in this Fabaceae member
1) Thalamiflorae and Bicarpellatae
2) Inferae and Disciflorae
3) Disciflorae and Bicarpellatae
4) Heteromerae and Disciflorae

35) Creeping stem striking roots at each node is found in this Asteraceae member
1) Tridax 2) Oxalis 3) Launea 4) Hydrocotyl

36) Tridax and Capsicum show similarity in
1) The position of their ovaries
2) The type of cohesion shown by androecium
3) The number of carpels and locule in gynoecium
4) The type of their fruits

37) Which of the following is not found in Nicotania?
1) Self pollination 2) Straight embryo
3) Bicollateral vascular bundles 4) Septicidal capsule

38) Type of inflorescence found in lily and glory lily respectively is
1) Solitary –terminal, Solitary –Axillary
2) Simple raceme, panicle
3) Simple umbel, Simple umbel
4) Solitary –Axillary, panicle

39) Taxonomy which is purely based on the description of morphological characters is
1) Omega Taxonomy 2) Artificial system
3) Alpha taxonomy 4) Phylogentic system

40) It is an international centre for identification and nomenclature of plants
1) Royal Botanic Gardens
2) Botanical survey of India
3) Central Institute of Medicinal and Aromatic Plants
4) National Botanical Research Institute

41) The credit using binomial system consistently for the first time goes to
1) Gaspard Bauhin 2) Linnaeus
3) Aristotle 4) Theophastrus
42) Naming of plants should be in accordance with the ----
1) B.S.I 2) N.B.R.I 3) I.A.R.I 4) I.C.B.N
43) Sexual system of Linnaeus in which floral characters are given importance belongs to
1) Synthetic system 2) Phylogenetic system
3) Natural system 4) Artificial system
44) Irrespective of its rank, every unit in the taxonomic hierarchy is called
1) Taxon 2) Species 3) Genus 4) Order
45) The correct hierarchial order of taxonomic units is
1) Genus, Family, order, series 2) Series, Order, genus family
3) Species, family, order 4) Class, subclass, order, series
46) Different families with similar characters are grouped into a
1) Series2) Class3) Order 4) Division
47) The following system of classification is popularly used in all Common Wealth countries
1) Linnaues 2) Engler & Pranti
3) Cronquist 4) Bentham & Hooker
48) Common character found in Thalamiflorae and Bicarpellate is the presence of
1) Gamopetalous corolla 2) Hypogynous flowers
3) Inferior ovary 4) Polypetalous corolla
49) Plants are classified into herbs, shrubs and trees by
1) Theophrastus 2) Linnaeus
3) Parasara 4) Charaka
50) The important prerequisite is Taxonomy is
1) Nomenclature2) Classification
3) Identification 4) Omega classification
51) Who classified plants into 50 groups based on medicinal properties and ecological associations?
1) Parasara 2) Linnaeus 3) Theophrastus4) Charaka
52) Selected the pair of characters which are more advanced
1) Monoecious condition & Inferior ovary
2) Simple leaves & Simple fruits
3) Unisexual flowers & Exalbuminous seeds
4) Free stamens & zygomorphic flowers
53) The characters of the series heteromerae are
1) Hypogynous flower & many carpels
2) Hypogynous flower & two carpels
3) Epigynous flower & Two carpels
4) Epigynous flower & Free petals
54) Bentham & Hooker classified the series Thalamiflorae into how many orders?
1) Four 2) Six 3) Five 4) Seven
55) It is difficult to know the following character with the help of floral formula
1) Epipetalous nature & position of ovary
2) Bisexual nature of Aestivation
3) Aestivation & placentation
4) Union of stamens & placentation

56) Bentham and Hooker classified dicotyledonate into three sub classes based on the
   1) Number of cotyledons & position of ovary
   2) Type of root system & venation
   3) Character of perianth & position of ovary
   4) Number of whorls in perianth & condition of petals

57) Flora of British India was written by
   1) Hooker 2) Bentham & Hooker
   3) Linnaens 4) Darwin

58) The following aspect is not related to the role played by Kew
   1) International centre for plant identification
   2) Publish Index Kewensis reference books
   3) Maitanains largest herbarium
   4) Prepare principles of classification

59) The basic unit of classification is
   1) Genus 2) Species 3) Family 4) Kingdom

60) The families are directly included under each series without the creation of orders in Benthaur & Hooker system is
   1) Thalamiflorae 2) Bicarpellate
   3) Calyciflorate 4) Coronaraiae

61) The families are directly included under each series without the creation of orders in Benthaur & Hooker system is
   1) Monocotyledous & Polypetalae
   2) Monochlamydae & Gamopetalae
   3) Monocotyledonae & Monochlamlydae
   4) Polypetalae & Gamopetalae

62) Gradual evolution of flower is seen in Polypetalae is associated with
   1) Hypogynous to epigynous 2) Epigynous to hypogynous
   3) Syncarpus to apocarpous 4) Gamopetalous to polypetalous nature

63) In the following series, the perianth is in two whorls, petals are fused and stamens are epipetalous in
   1) Calyciflorae 2) Disciflorae 3) Bicarpellatae 4) Coronariae

64) The first international Botanical congress was held in 1867 which formulated the
   1) Paris code 2) Sydney code 3) Berlin code 4) Tokyo code

65) The specific name of plant always starts with small letter and it is a
   1) Noun 2) Adjective 3) Adverb 4) Pronoun

66) Thalamus is elongated or conical in the series
   1) Calyciflorate 2) Inferae 3) Thalamiflorae 4) Disciflorae

67) Select the correct set of answers using the codes given

List –A	List –B
A) Linnaeus	I) General Plantarum
B) Theophrastus	II) Species Plantarum
C) Bentham & Hooker	III) Vrikshayurveda
D) Parasara	IV) Historia Plantarum

   1) A-I, B-III, C-IV, D-II 2) A-II, B-IV, C-I, D-III
   3) A-III, B-I, C-II, D-IV 4) A-IV, B-II, C-III, D-I

68) Select the incorrect pair
   1) Linnaeus – sexual system 2) Takhtajan –natural system
   3) Bessy – phylogenetic system 4) Goldberg – synthetic system

69) In Malvaceae, flowers are

1) Actinomorphic & Epigynous 2) Pentamerous & Hypogynous
3) Bisexual & Monochlamydeous 4) Hemicyclic & Hypogynous

70) In Gossypium fruit is
1) Schizocarp 2) Berry
3) Loculicidal capsule 4) Hemicyclic & Hypogynous

71) In the members of Malvaceae
1) Pollen grains are spinous 2) Anthers dehisce longitudinally
3) Anthers are dithecous 4) Anther shows four microsporangia

72) Self pollination in Malvaceae is prevented by
1) Heterostyly 2) Protogyny 3) Dicliny 4) Protandry

73) In Hibiscus sepals are
1) Free & Twisted 2) United & Valvate
3) United & Twisted 4) Free & Descendingly imbricate

74) Select the incorrect statement with respect to the characters of Hibiscus
1) Stellate hairs are found on the stem
2) Twisted corolla
3) Epicalyx is absent
4) Style passes through the staminal tube

75) In Gossypium fibers are obtained from
1) Stem 2) Seed 3) Root 4) Leaf

76) In Hibiscus, the number of carpels is equal to the numbers of
1) Locules & Stigmas 2) Ovules & Locules
3) Styles & Bracteoles 4) Locules & Stamens

77) In Hibiscus petals are
1) Totally free 2) Fused at the base with sepals
3) Fused at the base with staminal tube 4) Fused at the base with carpels

78) The following plant yields fibre
1) H.rosa –sinensis 2) H.micranthus
3) Sida cordifolia 4) H.cannabinus

79) The taxonomist who was responsible for starting botanical survey of India wrote a book known as
1) Genera Plantarum 2) Species Plantarum
3) Flora of British India 4) Historia Plantarum

80) Who classified plant kingdom into 50 groups based on medical properties and ecological associations
1) Parasara 2) Charaka 3) Theophrastus4) Linnaeus

81) Bentham & Hooker's classification was based on the system proposed by
1) de Candolle 2) Gaspard Bauhin 3) de Jussieu 4) Brunfels

82) Largest family among the angiosperms is the
1) Fabaceae 2) Asteracea 3) Solanaceae 4) Liliaceae

83) Plant tissues in the members of Malvaceae contain
1) Latex cells 2) Resin ducts 3) Mucilagneous cavities 4) Hydathodes

84) Common character found in Hibiscus and Datura is the presence of
1) Twisted aestivation of corolla
2) Bicarpellary syncarpous pistil
3) Cohesion of stamens
4) Number of stigmatic lobes equal to the number of carpels

85) Sida differs from Hibiscus in the absence of
1) Actinomorphic flowers 2) Pentamenous condition

3) Epicalyx 4) Calyx

86) A member of Asteraceae exhibit anemophily with fruits having hook like spines do not posess

1) Syngenesious anthers 2) Epipetalous stamens
3) Inferior ovary 4) Calyx

87) Common characters found in Lathyrus and Pisum are the presence of

1) Tendrils & Self pollination
2) Tree habit & syngenesious condition
3) Diadelphous condition & Bicarpellary pistil
4) Pulvinous leaf base & simple leaves

88) Anthers are monothecous but pollen grains are spinous in

1) Tridax 2) Hibiscus 3) Datura 4) Allium

89) Endosperm is abundant in the members of

1) Malvaceae 2) Fabaceae 3) Asteraceae 4) Solanaceae

90) Dicot members showing fasciculated tuberous roots

1) Asparagus & Ruellia 2) Dahila & Cichorium
3) Dahlia & Helianthus 4) Bryophyllum & Colchicum

91) A twiner that contains trifoliate leaves is the

1) Dolichos 2) Pisum 3) Cajanus 4) Lathyrus

92) Monadelphous and dithecous conditions are found in

1) Crotalaria & Abutilon 2) Arachis & Hibiscus
3) Arachis & Crotalaria 4) Sida & Tephrosia

93) Fruits are indehiscent and geocarpic in

1) Dolichos 2) Cicer3) Arachis 4) Calotropis

94) A plant belongs to Fabaceae provide fodder and produce fibre is

1) Cajanus cajan 2) Pisum sativum
3) Crotalaria juncea 4) Tephrosia

95) A xerophtye dehisce transversely in the members of

1) Tridax 2) Sphaeranthus3) Eichinops 4) Asparagus

96) Anthers dehisce transversely in the members of

1) Solanaceae 2) Malvaceae 3) Liliaceae 4) Fabaceae

97) Choose the incorrect pair

1) Protandry – Colchicum 2) Herkogamy – Gloriosa
3) Protogyny – some sp. of Solanum 4) Safety mechanism –Tridax disc florets

98) Choose the incorrect answer with regard to characters of Asteraceae

1) Basal placentation 2) Cohesion and adhesion of stamens
3) Fruit is siliqua 4) Stigma is bifid and hairy

99) Accerscent calyx is present in

1) Datura 2) Physalis 3) Capsicum 4) Solanum

100) Leaves of the following are useful for curing asthma

1) Atropa belladona 2) Nicontiana tabaccum
3) Solanum surratense 4) Capsicum frutescens

101) A gamopetalous family showing bicollateral vascular bundles is

1) Solanaceae 2) Cucurbitaceae 3) Malvaceae 4) Asteraceae

102) Select the incorrect answer with regard to the characters of Fabaceae

1) Pulvinious leaf base 2) Odd petal in anterior
3) Marginal placentation 4) Papilionaceous corolla

103) Septal the incorrect answer with regard to the characters of Fabaceae

1) Fabaceae 2) Asteraceae 3) Liliaceae 4) Malvaceae

104) Stipules are modified into tendrils and flowers are unisexual in
1) Ruscus 2) Smilax 3) Pisum 4) Cucurbita

105) Axile placentation is found in
1) Asteraceae & Malvaceae 2) Fabaceae & Solanaceae
3) Malvaceae & Liliaceae 4) Asteraceae & Liliaceae

106) Flowers are actinomorphic and trimerous in
1) Allium 2) Hibiscus 3) Dolichos 4) Datura

107) Disc florets differ from ray florets in the presence of
1) Bicarpellary pistil 2) Actinomorphic symmetry
3) Basal placentation 4) Persistant pappus

108) Gamosepalous calyx is present in
1) Gossypium & tridax 2) Dolichos & Helianthus
3) Tridax & Datura 4) Datura & Hibiscus

109) Carina are useful for
1) Assimilation 2) Attraction
3) Attracting the insects 4) Enclosing essential organs

110) Pyrethrum an insecticide obtained from which part of Chrysanthemum cinerarifolium?
1) Roots2) Leaves 3) Flowers 4) Fruits

111) The plant that possesses bacterial properties in the
1) Smilax 2) Aloe 3) Gloriosa 4) Allium cepa

112) The following combination of plants possess monadelphous stamens
1) Hibiscus & Crotalaria 2) Gossypiuim & Bombax
3) Tephrosia & Dolichos 4) Abutilon & Datura

113) The plant of Asteraceae with compound leaves and fasiculated tuberous roots is
1) Asparagus 2) Dahlia 3) Parthenium 4) Helianthus

114) Common character found both in Malvaceae and Solanaceae is the presence of
1) Epicalyx 2) Monadelphous stamens
3) Axile placentation 4) Multicarpellary ovary

115) The family Asteraceae can be distinguished from Solanaceae in the presence of
1) Bicarpellary ovary 2) Epipetalous stamens
3) Syngenesious anthers4) Gamopetalous corolla

116) Flowers are unisexual in
1) Gloriosa & Crocos 2) Ray florests of Tridax & Delonix
3) Tamarindus & Ruscus 4) Smilax & Ruscus

117) Pyrethrum is used as
1) Alcohol 2) Insecticide 3) Antimitotic drug 4) Rejuvenating tonic

118) Calyx is awn like in
1) Datura 2) Tridax 3) Xanthium 4) Helianthus

119) Fibre yielding plants belonging to Liliaceae
1) Allium & Gloriosa 2) Yucca & Dracaena
3) Ruscus & Dracaena 4) Colchicum & Asparagus

120) Leaves are bifoliate in
1) Dolichos 2) Delonix 3) Parkinsonia 4) Hardwickia

121) Pollen grains with spinous walls are seen in
1) Cassia 2) Tephrosia 3) Kydia 4) Datura

122) Name the plant that yields fibre and also produce leafy vegetable
1) Crotalaria juncea 2) Gossypium herbaceum

3) Yucca gloriosa 4) Hibiscus cannabinus

123) In Xanthium the following characters are present
1) Hook like spines & Synandry 2) Absence of calyx & Anemophily
3) Anemophily & Legume 4) Persistant calyx & monocarpellary ovary

124) Select the correct matching
1) Malvaceae –stellate hairs on stem
2) Solanaceae – stem shows collateral vascular bundles
3) Asteraceae – fruit is siliqua
4) Caesalpinaceae – basal placentation

125) Gossypium shows
1) Simple palmately lobed leaves 2) Loculicidal capsule
3) Diadelphous nature 4) Both 1 & 2

126) Common characters found in Malvaceae and Liliaceae are
1) Tremendous condition & Zygomorphic flowers
2) Actinomorphic flowers & axile placentation
3) Protandry & diadelphous nature
4) Multicarpellary pistil & mucilage ducts

127) A tree belongs to Solanaceae is the
1) Solanum melangina 2) Solanum surattense
3) Solanum verbascifolium 4) Datura metal

128) Stigmas are twice the number of carpels in
1) Hibiscus 2) Pavonia 3) Tridax 4) Gossypium

129) Flowers are actinomorphic, bisexual, pentamerous and hypogynous in
1) Liliaceae 2) Fabaceae 3) Malvaceae 4) Asteraceae

130) The seeds of the following are used as condiment and medicine
1) Trigonella 2) Tophrosia 3) Arachis 4) Pisum

131) The leaves are radical in
1) Helianthus 2) Parthenium 3) Allium 4) Xanthium

132) Ray florets in the Asteraceae are
1) Pentamerous, complete, actinomorphic & epigynous
2) Pentamerous, zygomorphic, male & epigynous
3) Incomplete, zygomorphic, female & perigynous
4) Incomplete, zygomorphic, female & epigynous

133) Berry is enclosed by inflated fleshy calyx in
1) Datura 2) Capsicum 3) Physalis 4) Cestrum

134) Smilax shows
1) Reticulate venation 2) Tendrillar stipules
3) Unisexual flowers 4) All

135) Mesophytes belong to Liliaceae are
1) Asparagus & Ruscus 2) Allium & Lilium
3) Aloe & Allium 4) Lilium & Ruscus

136) Carthamus tincotorius produces
1) Oil from seeds & dye from flowers
2) Oil and fibre from stem
3) Oil from roots & fodder from leaves
4) Oil from seeds & dye from leaves

137) Perianth is differentiated into calyx and corolla, petals are free in this series
1) Inferae 2) Coronoriae 3) Bicarpellatae 4) Thalamiflorae

138) The following is the official publication of the Royal Botanic Gardens, Kew
1) Historia plantarum 2) Origin of species
3) Flora of British India 4) Index kewensis
139) The classification which believes that all species are created by God is the
1) Artificial classification 2) Natural classification
3) Phylogenetic classification 4) Synthetic classification
140) The series inferae comprises the following three orders
1) Ericales, Primulales & Ebenales
2) Gentianales, Polemoniales & Personales
3) Rubiales, Asterales & Campanulales
4) Campanulales, Polemoniales & Rubiales
141) Which one among the following possesses relatively more advanced character?
1) Inferior ovary & compound leaves
2) Bisexual flowers & free stamens
3) Polypctalous corollae & multiple fruit
4) Hypogynous flowers & actinomorphic flower
142) In the Bentham & Hooker's system, while classifying monocotyledonate importance is given to the
1) Leaf morphology 2) Position of the ovary
3) Perianth characters 4) Both 2 & 3
143) Fabaceae differ from Malvaceae by having
1) Tetramerous flowers 2) Anterior odd sepals
3) Zygomorphic flowers 4) 2 & 3
144) The common character in all the members of Fabaceae is the presence of
1) Herbaceous nature 2) Allogamy
3) Symbiotic nitrogen fixation 4) Simple leaves
145) Crotalaria shows
1) Simple leaves & monadelphous condition
2) Trifoliate leaves & monadelphous nature
3) Pulvinous leaf base & Diadelphous nature
4) Samara & syngerious nature
146) In Tephrosia, all the
1) Stamens are united 2) Petals are united
3) Carpels are united 4) Sepals are united
147) Select the correct matching using the codes given below:

List –I	List –II
A) Tree	I) Arachis
B) Annual herb	II) Dolichos
C) Twiner	III) Lathyrus
D) Tendril climber	IV) Pterocarpus

1) A-I, B-III, C-II, D-IV 2) A-IV, B-I, C-II, D-III
3) A-II, B-IV, C-III, D-I 4) A-III, B-II, C-IV, D-I
148) Stipules are persistant and leaf like in
1) Rosa 2) Arachis 3) Pterocarpus 4) Spinous
149) In Ulex, leaflets are
1) Absent 2) Foliaceous 3) Scale like 4) Spinous
150) In the following stem is prostrate and decumbent showing heterogamous head
1) Helianthus 2) Tridax 3) Cichorium 4) Echinops

Keys

Ex –1

1)3	2)2	3)3	4)2	5)2	6)4	7)4	8)3	9)3	10)2
11)2	12)2	13)3	14)1	15)2	16)3	17)1	18)2	19)2	20)3
21)1	22)2	23)4	24)4	25)4	26)2	27)2	28)4	29)2	30)1
31)3	32)4	33)3	34)4	35)3	36)3	37)4	38)1	39)3	40)1
41)2	42)4	43)4	44)1	45)4	46)3	47)4	48)2	49)1	50)3
51)4	52)3	53)1	54)2	55)3	56)4	57)1	58)1	59)4	60)3
61)3	62)1	63)3	64)1	65)2	66)3	67)2	68)2	69)2	70)3
71)1	72)4	73) 2	74)3	75)2	76)1	77)3	78)4	79)3	80)2
81)1	82)2	83)3	84)1	85)3	86)4	87)1	88)2	89)4	90)2
91)1	92)3	93)3	94)3	95)3	96)2	97)1	98)3	99)2	100)3
101)1	102)2	103)3	104)2	105)3	106)1	107)2	108)4	109)4	110)3
111)4	112)1	113)2	114)3	115)3	116)4	117)2	118)4	119)2	120)4
121)3	122)4	123) 2	124)1	125)4	126) 2	127)3	128)2	129)3	130)1
131)3	132)4	133)3	134)4	135)2	136)1	137)4	138)4	139)4	140)2
141)1	142)4	143)4	144)3	145)1	146)4	147)2	148)4	149)4	150)2

UNIT –V
CELL : STRUCTURE AND FUNCTION

- The Study of structure and function of cell is called **Cytology** or **Cell Biology**
- Robert Hook discovered the cell while observing the slices of bark under a microscope, he also coined the term cell (cell in latin means hollow space) for compartment like units in the slice of Bark
- Hooke described his observations in the titled as MICROGRAPHIA
- Anion Von Leeuwenhoek described the structure of Red blood cells, protozoa and bacteria
- Ductch scientist Corti and Fontana identified the presence of jelly like substance (protoplasm) in the cell
- Dujardin named the jelly like substance as SARCODE
- The term PROTOPLASM for jelly like substance was coined by Purkinje
- Robert Brown reported the presence of nucleus in the protoplasm
- Apart form the structural aspects of cell, the biochemical, genetic and functional aspects of cell came to light branches like Biophysics, Biochemistry, Physiology, Genetics etc

A few important theories proposed in Cytology:

- The cell theory was proposed by German botanist M.M.Schleiden (1838) and zoologist T.Schwann (1839)

Cell theory an important land mark in biological research and it states that

- Cell is the structural unit of all organisms
- Cell is the functional unit of all organisms
- Cell lineage theory (Omnis cellulase –e- cellulase) was proposed Rudolf Virchow which says that new cells arise from preexisting cells. Cell as hereditary unit of all organims was added to cell theory

TYPES OF CELLS:

1) Prokaryotic cells 2) Eukaryotic cells

- Prokaryotic nucleus is represented by single, circular, naked DNA molecule and called as a ‘ nucleoid’
- Eukaryotic cells are found in all major plant and animal groups
- Eukaryotic cells are an advanced type and have complex organisation
- Eukaryotic cells possess definite nucleus with nuclear envelop, chromatin and nuclear sap

ULTRA STRUCTURE OF PLANT EUKARYOTIC CELL

- The two major parts of the plant cell are
  1) Cell wall 2) Protoplasm
- A plant cell without cell wall is called PROTOPLAST

1) **Cell wall**

- Presence of cell wall is characteristic of plant cells. It is permeable to all substances
- The cell wall is the secretion of Protoplasm
- The cell wall is tough and made up of hard, rigid, and non living components
- A mature plant cell has three layers in the wall called as
  A) Middle lamellum B) Primary wall C) Secondary wall

A) Middle Lamellum

- Middle lamellum is the cementing substance between the two adjacent cell walls

- Middle lamellum is composed of pectates of calcium and magnesium
- The cell plate develops into the middle lamellum during cell division
- The Golgi vesicles and vacuoles migrate into the phragmoplast and form the cell plate

B) Primary wall

- The primary wall is the deposition of cellulose, hemicellulose, pectin and other polysaccharides on the either sides of Middle lamellum
- The primary wall is thin and elastic in nature
- The primary wall has pectinous matrix with the frame work of cellulosic microfibrils

C) Secondary wall

- After the complete growth of the cell, the secondary wall is formed on the inner surface of the primary wall
- Seconday wall is hard, tough and inelastic due to the deposition of lignin
- Lignin gives rigidity, hardness and tough nature to the cell wall
- The unthickened areas of secondary wall (without lignified thickenings) are termed as PITS
- Pits of two adjeacent cells pair up to form a PIT PAIR
- Pits may be formed over the primary pit fields or even without them
- Pits are of two types
- Simple Pits: A pit whose cavity is uniformly wide on all sides
- Bordered Pits: A pit where in secondary wall bends as an arch, over the cavity
- The portion of middle lamella which crosses the bordered pit is thickened at the center to form a lens shaped thickening called TORUS
- Growth in the cell wall surface area is known as 'Intussusception'
- Growth in the cell wall thickeness is known as 'Apposition'

2) Protoplasm

- Protoplasm is a transparent, viscous, colloidal solution described as SARCODE by Corti and Dujardin
- The term protoplasm was coined by Purkinje
- Von Mohl described protoplasm as the seat of several biological processes
- Protoplasm is delimited by a thin membrane called as **Plasmalemma or Plasma membrane**

Physical and Chemical properties of protoplasm

- Protoplasm exists in sol (dilute solution) or Jel (Jelly like) states
- Protoplasm exhibits Brownian movement and Tyndal effect. (bending of light at right angles to the incident ray)
- Specific gravity of protoplasm is greater than one
- p^H of protoplasm is slightly higher than 7 and shows alkaline properties
- Water content in the protoplasm is 85%
- The proteins, enzyme, aminoacids, carbohydrates, fats, oils, pigments and hormones constitute organic compounds of protoplasm
- Salts of calcium, magnesium, iron, iodine, sodium, potassium etc, constitute the inorganic compounds
- Nearly 40 types of inorganic substances have been detectedin protoplasm
- The organic and inorganic substances of protoplasm together constitutes 15%
- Protoplasm coagulates and dies when heated upto 60^0C
- The electric shock, strong acids, alcohol, toxins etc. also cause coagulation and death of protoplasm
- Biological properties like growth metabolism, reproduction and irritability (response to stimulus) are exhibited by protoplasm

- The protoplasm can be divided into two major parts namely NUCLEUS and CYTOPLASM
- The protective layer around the protoplasm is cell membrane or plasma membrane

A) Cell Membrane or Plasma Membrane or Plasma Lemma

- It is living membrane present beneath the wall and measuring about 7.5nm is thickness
- It is closely appressed to the cell wall but its free nature from cell wall can be seen in a plasmolysed cell when it detaches from the cell wall
- It shows the presence of three layers in electron microscope
- It is made up of phospholipids and proteins
- The two prominent theories explaining the strcture of Plasma lemma are
  1) Sandwich Model 2) Fluid Mosaic Model

1) Sandwich Model or Unit Membrane Model or Trilamellar Model

- Sandwich model or unit membrane model or trilamellar model was proposed by Davson and Danielli
- According to this model two dark layers composed of proteins present on the either sides of middle colourless layer of two rows of phospholipid molecules
- According to Robertson all membranes show protein –lipid- protein arrangment hence called as 'unit membrane'

2) Fluid Mosaic Model

- Fluid mosaic model was proposed by Singer and Nicholson
- According to the fluid mosaic model the cell membrne is a semisolid layer showing elasticity and differential (selective) permeability
- The differential permeability is due to liquid matrix state of lipids accommodating protein molecules in mosaic pattern
- Protein molecules float in the sea of lipid molecules like the ice bergs float in an ocean
- The fluid mosaic arrangement of proteins and lipids helps to regulate the entry and exit of substances through it and plays role in the osmoregulatory process of cell

B) Cytoplasm

- The protoplasm excluding nucleus is called cytoplasm
- It is a transport, viscous, colourless fluid extending from cell membrane to nuclear membrane
- The cytoplasm is mainly composed of water (85-90%), proteins (7-10%), fats (1-2%) and other organic mataerials (1-5%)
- The cytoplasmic matrix is homogenous with cytoskeleton formed by microtubules and microfilaments
- The cytoplasm is not stationary and exhibits rotatory and circulatory movements

I) Rotation

- It is the movement occurring in a regular direction around the vacuole
  Ex: Hydrophytes like Hydrilla and Vallisnaria

II) Circulation

- It is movement occurring in zig-zag (clockwise and anticlockwise) manner around many vacuoles in the cell
  Ex: Staminal hairs of Rheo discolor
- The cytoplasm is distinguishable into cell organelles and ergastic substances

A) Cell Organelles

- The membrane bound structures that perform different functions and keep the cell in a dynamic state
- The cell organelles include the Endoplasmic reticulum, Ribosomes, Golgicomplex, Plastids, Mitochondria, Vacuoles, Lysosomes, Peroxisomes, Glyoxisomes etc

1) Endoplasmic Reticulum (ER)

- ER is a network of lipoprotein molecules extending from outer nuclear membrane to cell membrane
- ER was reported by K.R.Porter and it is characteristic of eukaryotic cell
- ER is composed of cisternae, vesicles and tubules
- ER is made up of two unit membranes separated by a space
- The two forms of ER are granular ER and granular ER
- **Granular ER** or **rough ER** is studded with ribosomes on the surface and helps in proteins synthesis and Glycogen storage
- **Agranular ER** or **smooth ER** is smooth surfaced due to the absence of ribosomes and it helps in lipid synthesis
- ER also helps in production of golgicomplex and cell plate
- ER acts intracellular transportation channel

2) Ribosomes or Ergosomes

- Ribosomes are tiny ribonucleoprotein structures reported by **Palade**
- Ribosomes are present in the nucleolus and transported into cytoplasm
- These are produced in the nucleolus and transported into cytoplasm
- These are free floating in the cytoplasm or attached to E.R.membranes
- Based on the sedimentation coefficient (Svedberg unit –S) the ribosomes are two types: **70 S** (Pro & eukaryotes), **80 S** (Only eukaryotes)
- The ribosomes measure about 23 nm in diameter and composed of two sub units, the upper subunit being smaller and lower subunit in size
- The two subunits of 80 S are 60 S and 40 S, where asw that of 70 S are 50 S and 30 S
- The two subunits of any ribosome are held together in presence of magnesium ions
- The long chain of ribosomes formed during protein synthesis in prokaryotes known as polysomes or polyribosomes
- The ribosomes in polysomes are associated with messenger RNA
- The polysomes translate the genetic message of m-RNA for protein synthesis
- Ribosomes contain the enzyme known as 'peptidyle transferase'
- The enzyme peptidyle transferase helps in peptide bond formation between the aminoacids to form polypeptide (protein) molecule
- Due to the presence even in primitive organisms like bacteria, the ribosome are considered as most primitive organelles

3) Golgi complex or Lipochondria or Idiosomes

- It was first reported by **Camillo Golgi**, hence the name **Golgi complex**
- Golgi complex occurs in Eukaryotic cells only
- The golgicomplex in plant cells exists as 1-15 units called as DICTYOSOMES
- Each dictyosome is distinguishable into 3-7 cisternae, sacs, vacuoles and tubules
- The cisternae are flattened
- The structures in the dictyosomes are single membraned and filled with an amorphous substance

Functions:

- Synthesis of cell wall, materials like cellulose, hemicellulose, pectin and polysaccharides
- Secretion of lipids, hormones and enzymes
- Production of lysosomes and formation of cell plate

4) Plastids

- The plastids were reported by Leeuwenhoek, but named by Schimper

- Presence of plastids is characteristic feature of plant cells and they arise from proplastids
- Plastids are absent in Animal cells and some plant cells like Fungi and bacteria
- Based on the pigmentation the plastids are classified into three types namely
  1) Leucoplasts 2) Chromoplasts 3) Chloroplasts

1) Leucoplasts

- Colourless plastids helping in storage of organic food materials known as leucoplasts
- Leucoplasts occur in tissues which are deep and not exposed to sunlight
- Leucoplasts storing starch called as Amyloplasts, storing proteins are called as Aleuroplasts and storing fats and oils called as Elaioplasts

2) Chromoplasts

- Plastids with orange yellow and red pigmentation are known as chromoplasts
- The plastids occur in the cells of petals, pericarp, leaves, seed coat, tubers, roots etc
- They help in pollination, dispersal of fruits and seeds
- Different types of pigments in chromoplasts impart different colourations to plant parts
- The pigement carotenes and xanthophylls together known as carotenoids
- Caroot roots have carotenes, which imparts orange colour
- Red colour of tomato fruits is due to the pigment called **Lycopene**
- Red colour of red algae is due to the pigment **phycoerythrin**
- Blue colour of blue green algae is due to the pigment **phycocyanin**
- Brown colour of brown alage is due to the pigment **fucoxanthin**
- Phycocyanins, phycoerthrins and fucoxanthin are together known as '**phycobilins**'

3) Chloroplasts

- Green coloured plastids are called as chloroplasts which measure 4-6μ in length and 1-3 μ in diameter
- The vacuoles in the young plant cells are more in number and small in size
- The mature plant cell consists of single, large vacuole due to the fusion of small vacuoles
- The vacuole in the mature plant cells is centrally located and pushes the cytoplasm to the periphery
- The cytoplasm present as a thin layer around the vacuole is known as primordial utricle
- The cell sap is composed of water, anthocyanin pigments, metabolic byeproducs, secretes and waste materials
- The anthocyanin pigments impart blue, pink and violet colours (non-photosynthetic pigments)
- Vacuoles also help in osmoregulatory processes of cells

7) Lysosomes or Suicidal bags of cells

- Lysosomes are single membrane bound organelles filled with enzymatic matrix
- They measure 0.4 to 0.8μ in diameter
- The enzymatic matrix is rich in hydrolytic and phospholytic enzymes
- The lysosomes are in large numbers in Meristematic cells
- The lysosomes were first reported by Christian de Duve
- They orginate from endoplasmic reticulum or golgicomplex
- The lysosome help in the digestion of food materials, microorganisms and old cells
- The lysosomes cause autolysis of cell contents, hence known as suicidal bags of cells
- Lysosomes are three types namely, thus exhibits POLYMORPHISM
  1) Primary lysosomes
     They contain the enzymatic fluid
     They are spherical vesicles

2) Secondary lysosomes
They contain food molecules or microorganisms
3) Tertiory lysosomes (Residual Bodies)
They contain undigested materials

8) Peroxisomes
- These are single membraned spherical organelles, measuring 0.7µ in width
- Peroxisomes were first reported by **Rhodin**

9) Glyoxisomes
- These are also single membraned, spherical organelles
- They were reported by **Bridenbach**
- They contin enzymes of glyoxalate cycle that involves the conversion of fats into **carbohydrates**

C) Ergastic Substnaces or Non Living Inclusions of Cell
- These are non living materials formed as end products or bye products of various metabolic reactions in protoplasm
- These are found in dissolved state or suspended from as crystals, solids or liquids
- These are stored in cell walls or cell organelles or cell orgtnaelles or vacuoles

D) Nculeus
- Nucleus is a spherical ball like structure which controls and coordinate various life activities in the cell
- Nuclues was discovered by Robert Brown
- Generally each cell consists of one nucleus (**monokaryotic**)
- Cells with two nuclei (**diakaryotic**) are seen in Ascomycetous and Basidiomycetous fungi and Tapetal cells
- Cells with many nuclei (**coenocytic**) are seen in some algae like Vacheria, some fungi like Mucor and Rhizopus
- Nuclei are absent in mature sieve tubes (anucleated)
- The four parts in the nucleus are
  1) Nuclear membrane
  2) Nucleoplasm
  3) Chromatin material
  4) Nucleolus

1) Nuclear membrane (Nuclear envelop)
- It is double membraned envelope and present in eukaryotic cells
- The two membranes are lipo-proteinaceous in nature, about 7.5µm thick
- The nuclear envelop is porous and establishes contact between nuceloplasm and cytoplasm
- The nuclear envelop is absent in prokaryotic cells

2) Nucleoplasm (Nuclear sap)
- It is homogenous, semisolid substance inside the nucleus
- The nuceloplasm is composed of glycoprotein, ribonucleoproteins, hydrolyzing enzyumes, DNA and RNA polymerases and chromatin material

3) Chromatin material
- It is deeply stained network like substance, associated with **histone proteins**, during the interphase
- It was first observed by **Hofmeister**
- During cell division it forms rod shaped structures called as ‘Chromosomes’
- A chromatin fibre under an electron microscope reveals many repeated units called NUCLEOSOMES

- The term nucleosomes was coined by OUDET
- Each nucleosomes has a core, which is made of a **Histone Octamer**
- The histone octomaer, comprises of 2 units each of $\mathbf{H_2A}$, $\mathbf{H_2B}$, $\mathbf{H_3}$ and $\mathbf{H_4}$ proteins
- The core of the nucleosome is wrapped by 166 base pairs of DNA, to form the super coil
- All the abjacaent nucleosomes are joined together by LINKER DNA
- Each nucleus consists of one or two many spherical deeply stained bodies called as **nucleoli** or **plasmosomes**
- Nucleoi were first reported by **Fontana**
- Central part of nucleolus is fibillar and peripheral part is granular
- Nucleolus develops from secondary constriction (Nucleolar organizing region –NOR) of a specialized chromosome
- Nucleolus is made up of RNA, proteins and little amount of DNA
- Nucleolus function is ribosomes synthesis
- Nucleoli function is ribosomes synthesis
- Nucleoli and nuclear envelop disappear during (prophase of) nuclear division and reappear during cytokinesis

Functions of Nucleus

- It is referred as the **dynamic centre of cell** or **master organelle** or **cell brain** because it controls the functions of all cell organelles
- Nucelus helps in transfer or hereditary characters
- Nucleus helps in the reproduction of unicellular organisms

Chromosomes

- **Karl Nageli** observed the chromosomes for the first time, (as deeply stained thread like structures) in nucleus
- **Hofmeister** observed the chromosomes, later in a dividing nucleus
- **Waldehyer** coined the term chromosomes (**chroma** = colour, **soma** = body)
- Chromosomes appear during cell division
- Chromosomes are involved in controlling and regulating cell activities and transfer of genetic traits from one generation to next generation
- Chromosomes, therefore are referred as '**physical basis of heredity**'
- According to chromosomal theory proposed by Sutton and Boveri the chromosomes are 'hereditary vehicles'
- Chromosomal number is constant in each species
- The size, shaped and structure of chromosomes also differ from species to species

Size

- Plant chromosomes are bigger is size than animal chromosomes
- The bigger chromosomes are seen in Trillium (about 30µ in length) –a Lilliaceae member

Shape

- Chromosomes are stout and rod shaped during metaphase
- Chromosomes are **V** or **L** or **I** shaped during anaphase of cell division
- In prokaryotes like Bacteria, the chromosomes are circular and ring like

Number

- In the nucleus of vegetative cells of higher plants and animals the chromosomes are in 2 sets and represented as diploid (2n) condition

- In gametes only one set of chromosomes are present and represented as haploid (n) condition
- **Karyotype** is the diploid of chromosomes in an organism, depicting size, shape and structure
- **Idiogram** is the diagrammatic representation of a karyotype
- Genome/Basic set is the single set of chromosomes (haploid set). It is denoted by '**n**'

Structure

- The morphology of a chromosome can be best studied during METAPHASE of cell division, due to maximal condensation
- A typical metaphase chromosome has 5 parts
  1) Centromere 2) Arms 3) Telomeres
  4) Secondary constriction 4) Satellite /Trebent

1) CENTROMERE: Is the non-stainable part of the chromosomes
   It is also called as Primary constriction

- The Centromere is intum made of two semicircular discs called KINETOCHORE which helps in the addition of microtubules to the spindle fibres
- The centromere on its either sides will bear arms

2) ARMS of a chromosomes contain two threads called CHROMONEMATA

- Chromonemata run from pole to pole of a chromosome through the centromere
- Chromonemata help in the formation of chromatids
- Chromatids are the vertically split arms
- Chromonemata bears certain active genetic centre called Chromosomes
- CHROMOSOMES are swelled up to form KNOBS
- TELOMERES are the specialized tips of the chromosomes
- They maintain the polarityb of chromosome & prevent the fusion of chromosomes
- SECONDARY CONSTRICTION: One of two secondary constrictions appear on a chromosome, other than the primary constriction
- Secondary constriction helps in the formation of nucleolus hence called NUCLEOLAR organizers
- The content inside the trebent is called SAT (Since Acid Thymonucleinico) (without DNA)

Chemistry of chromosomes

- Chromosomes are composed of genetic material called as DNA, which is associated with histone proteins
- The light stained areas are as 'EUCHROMATIN' and posses active genes
- This differential stainability is called as HETERO PYCNOSIS

Classification of chromosomes

- Chromosomes are classified into 5 types based on the number of centromeres
  1) **Acentric** are those without centromere
  2) **Monocentric** are those with one centromere
  3) **Dicentric** are those with two centromeres
  4) **Polycentric** are those with many centromeres
- Monocentric chromosomes are classified into 4 types, based on the position of centromere

1) METACENTRIC are those with centromere at the center and with two equal arms

- Metacentric appear '**V**' shaped during anaphase

2) SUBMETACENTRIC are those with centromere slightly away from the middle point and with unequal arms

- Submetacentric appear '**L**' shaped during anaphase

3) ACROCENTRIC are those with centromere more towards one side and with one very long arm while the other arm is very short

4) TELOCENTRIC are those with centromere present at one end

- Telocentric appear '**I**' shaped during anaphase
- Based on the function the chromosomes are two types
  1) **Autosomes**: They are more in number and determine somatic or vegetative activities such as growth, development
  2) **Allosomes** or sex **chromosomes**: They are less in number and determine the sexual characters of organisms
- In human beings they are identified as X, Y chromosomes

BIO MOLECULES

- All compounds (or) molecules as organic compounds normally present as essential components of living organisms –lehninger etal.
- All compounds (or) molecules present in the living tissues are called biomlecules.
- A maximum of 30 elements are required by living organisms in the formation of their innumerable number of chemicals.
- All the corbon compounds that we get from living tissues can be called biomolecules.
- Four elements of corbon, hydrogen, oxygen and nitrogen constitute 97-99% of the body of living organisms. They are called big four
- Carbon constitutes more than 50% of the dry matter.
- The essential organic compounds are also called as metabolites.
- Metabolites are formed in living beings as a result of their metabolic activity.
- Metabolites are of two types, primary and secondary.
  i) Primary metabolites are biochemicals formed as intermediates and products of normal vital metabolic pathway of organism eg: aminoacid, nucleolides sugars, fats.
  ii) Secondary metabolites are specialized products formed by alternation of normal (or) primary metabolic pathways. Eg: Aromatic compounds, alkaloids.

A comparison of elements present in non living and living matter

Element	**% weight of**	
	EARTH CRUST	HUMAN BODY
Hydrogen(H)	0.14	0.5
Carbon(C)	0.03	18.5
Oxygen(O)	46.6	65.5
Nitrogen(S)	Very Little	3.3
Sulphur(S)	0.03	0.3
Sodium(Na)	2.8	0.2
Calcium (Ca)	3.6	1.5
Magnesium(mg)	2.1	0.1
Silicon(Si)	27.7	Negligible

Secondary Metabolites

Pigments	Caretonoids	Anthocyanins
Alkaloids	Morphine	Codeine
Terpenoids	Monoterpenes	Diterpenes
Essential Oils	Lemon grass	
Toxin	Abrin	Ricin
Lectins	Concanavalin A	
Drugs	Vinblastin	Curcumin
Polymeric Substances	Rubber, gums	cellulose

The Entire collection of biomolecules (or) Metabolites is called metablome.
Analysis of Biomolecues.

Biomolecules are ground in Trichlorcelic acid by pestle and mortar

↓

Thick soup

↓

Strained through cheese cloth (or) cotton

↓

Filtrate called acid soluble pool Remaining retentate-acid insoluble pool

- Acid soluble pool contains with small molecular mass of 18-800 daltons. They are biomicromolecules.
- Bio micromolecules are soluble in trichloroacetic acid.
- Acid insoluble pellet contains chemical with large sized, high mass more than 800 datlons(Da). They are biomacromolecules.
- Biomacromolecules are insoluble in trichloroacetic acid. Eg. Proteins, nucloicacids and polysaccharides.
- Inorganic salts and ions occur in living bodies. They can be known through analysis of acid soluble pool (or) ash analysis.

Biomolecules:

Carbohydrates:

- These are polyhydroxy aldehydes (or) ketones
- Empirical formula is $C_n(H_2O)_n$ (or) $(CH_2O)_n$ where ni6 3-7
- They are also called saccharides (or) sugars (or) staff of life.

Carbohydrates (3types)

Monosaccharides
Monomers

colourless
Sweet to taste

$(CH_2O)_n$
(n=3to7)

5 types → Trioses → Tetroses → Pentoses → Hexoses → Heptoses

Eg: Maltose-maltsugar
Lactose-milk sugar
Sucrose-cane sugar
Fructose –fruit sugar
Glucose-Grape sugar
- Blood Sugar

Test → Benedict's Test
Test → Fenling Test

Oligosacoharides
Formed by condensation of monosaccharides

3 types → Trehalose → Trisaccharides → Tetrasaccharides

Polysaccharides
Polymers

Not sweet to taste
Also called pentosan (or) Hexosan
Also called araban (or) xylan
Eg: Starch, Glylogeninulin, cellulose chitin

Proteins:
These are large sized mixed polymers (or) heteropolymers
These are most abundant organic molecules of the cell.
Excess proteins are deaminated and changed to cargohydrates and fats.

Some proteins and their functions

Protein	functions
Collagen	Intercellular ground substance
Trypsin	Enzyme
Insulin	Harmone
Antibody	Fights infections agents
Receptor	Sensory reception
GLUT-4	Enables Glucose transport into cells
Actin myosin	Contractic proteins of muscles
Haemoglobin	Transport O_2
Serum albumin	Translocates fatty acids

Sclero proteins	Found in epidermal structures, skeleton
Vitellin	Egg yolk
Lactalbumin	Milk
Hordien	Barley grains
Histones	Nucleic acids

- most abundant protein in organic world/ RUBISCO
Whole of biosphere
- most abundant protein in Human body - collagen
- most abundant protein in animal world- collagen
- visual pigments like Rhodopsin & iodopsin are made of proteins
- Antifreeze proteins present in blood plasma of Antarctic fish.

NUCLEIC ACIDS

- The phosphorus rich giant molecules present in the nucleus are called nucleic acids
- The biochemical activites leading to growth and development of organisms are caused by Nucleic acids
- Joseph Fredrick Meischer (Swiss Scientiest) discovered the nucleic acids in the nuclei of pus cells
- Altman coined the term ‘nucleic acid’
- The nuclei acidsare two types namely
  1) DNA 2) RNA

DNA (Deoxyribo Nucleic Acid)

- DNA occurs more in chromosomes (Nucleus) and less in chloroplasts and Mitochondria
- **DNA is the genetic material in all organisms except in plant viruses**
- **Hershey** and **Chase** showed the genetical nature of DNA by transduction experiments
- DNA is referred to as chemical basis of heredity

Structure of DNA:

- Double helical model of DNA structure was proposed by **J.D.Watson** and **F.H.C.Crick**
- Watson and Crick model of DNA molecule was based on

1) X-ray diffraction (crystallography) by **Franklin** and **Wilkins**
2) **Chargaff's** chemical analysis which showed 1:1 ratios of purines and pyrmidines
3) **Pauling's** proposal of hydrogen bonds between the nitrogen bases

- DNA molecule is composed of two strands, spirally coiled with **antiparallel** arrangment
- The two strands are closely held by hydrogen bonds
- The diameter of DNA molecule is **20A^0**, but length is uncertain like a twisted ladder
- Each strand of DNA is polynucleotide chain (polymer and nucleotides)
- The nitrogen bases of DNA are 4 types namely **adenine** (A), **guanine** (G), **cytosine** (C) and **thymine** (T)
- Any nucleotide consists of one of these four types, hence nucleotides are also 4 types based on the type of nitrogen base
- Adenine and guanine are called as **purines**, while cytosine and thymine are called **pyrimidines**
- **Purines** are heterocyclic and consist of two C-N rings
- **Pyrimidines** are homocyclic and consists of one C-N rings

- In a nucleiotide the sugar and nitrogen base together called as '**Nucleoside**'
- Nucleoside with phosphate called as **Nucleotide**
- The backbone of polynucleotide strand is formed by alternate arrangement of phosphate and sugar group
- The sugar and phosphate groups are linked by **phospodiester bond**
- Nitrogen base is attached to the sugar group on lateral side is a nucleotide
- The two strands (polymers of nucleotides) of DNA are linked by their nitrogen bases
- The bond formation is always between a purine and pyridine, hence they are 1:1 ratio
- The nitrogen bases A, T and G, C are complementary to each other
- A of a nucleotide in one strand forms hydrogen bonds with T of a nucleotides in opposite strand and vice versa (A = T, T = A)

Properties of DNA:

- Molecular weight of DNA is very high (30,000 to several millions)
- The absorption spectrum of DNA is high at ultraviolet (260mμ) light
- DNA is dentatured when heated upto 70^0C
- DNA is dentatured at high pH and low salt conditions
- It is the chief genetic material in all organisms **except plant viruses**

Types of DNA :

- It was discovered separately by **Rodely** group in NewZealand and **Sashi Sekharan** group in India
- In a bacteriophage virus called φx174 phage, the DNA is single stranded

Functions of DNA:

- It is the duplication of single DNA into two daughter DNA molecules
- During this process two strands of DNA unwind and separate from each other
- The two strands separate of the break of hydrogen bonds between complementary strands
- The enzyme endonuclease helps in the breakage of hydrogen bonds
- The unwinding starts at one end and proceeds to other end
- Each separate strand acts as a template and synthesized a new complementary a strand with the help of the enzyme called **DNA polymerase**
- The template and complementary strand together form a new daughter DNA, thus two daughter DNA molecules are formed by two templates

RNA (Ribose Nucleic Acid)

- It is present more in ribosomes and cytoplasm and little in chloroplasts and mitochondria
- It is synthesized in the nucleus with the help of DNA by the enzyme called 'RNA-Polymerase' but later released into cytoplasm

RNA is of two types:

1) **Non-genetic RNA** helps in protein synthesis
2) The **genetic RNA** functions as genetic material and found in plant viruses ex: TMV

Structures of RNA:

- It is made of single polynucleotide strand
- However it is double stranded in **Reo virus** and **wound tumour virus**
- The nucleotides of RNA consits of three components namely
  1) Phosphate group 2) Ribose sugar ($C_5H_{10}O_5$) 3) Nitrogen base
- The nitrogen bases are four types namely **Adenine** (A), **Guanine** (G), **Cytosine** (C) and **Uracil** (U)
- Uracil differs from Thymine in lacking a methyl (CH_3) group

Types of non-genetic RNA:

- The three types of non-genetic RNA are
  1) Messenger RNA (mRNA) 2) Ribosomal RNA (rRNA
  3) Transfer RNA (tRNA)

Messenger RNA (mRNA):
- It was discovered by Jacob & Monad
- It is straight single polynucleotide stranded and occurs in the cytoplasm
- The mRNA constitutes 5-10% of total cellular RNA and is higly unstable
- Each strand consists of about few hundreds of nucleotides
- It is synthesized by DNA template by the process of 'transcription' in the nucleus and transported into cytoplasm
- Its molecular weight is about 5,00,000
- It is ephemeral is prokaryotes and lives for only 2 minutes
- It lives for about 4 hours in eukaryotes
- It has genetic information for specific protein synthesis
- The genetic message or information is present, in the form of triplet codons which are of 64 types
- The three nonsense codons are UAA, UAG, UGA

Differences between DNA and RNA:
- DNA consists of two strands of nucleotides nucleotides while RNA consists of one strand of nucleotides
- Most of the DNA occurs in nucleus while most of RNA occurs in the cytoplasm
- Little of DNA present in chloroplast and mitochondria, whereas little of RNA in nucleus, chloroplasts and mitochondria
- DNA replicates where as RNA does not replicte
- DNA is genetic material where as RNA (mostly) is not genetic material
- DNA does not participate directly in protein synthesis where as RNA directly takes part in protein synthesis.

CELL DIVISION

- Cell division is essential for growth and reproduction in organisms
- Growth in multicellular organisms is due to the cell division, cell elongation and cell differentiation
- Every living organism begins its life as a single cell called '**zygote**'
- Rudolf Virchow first proposed that new cells arise from pre-existing cells by division (omnis cellulae –e-cellula), which is known as **cell lineage theory**
- Cell divisions are two types namely
  1) Mitosis 2) Meiosis

Mitosis or Equational division or Somatic division:
- Mitosis was first observed by **Walter Flemming** in Animal cells
- Later on it was observed by **Strasburger** in plant cells
- One cell on mitosis gives rise to two daughter cells, which are identical to mother cell in size, shape and characters, hence the name **equational division or homotypic division**
- It occurs in vegetative or somatic cells
- It is common in apical meristems of Root and Stem
- It helps in the increase of size, shape and volume of the plant body

Stages of cell cycle:
- The cell cycle involves two stagesw namely
  1) Interphase 2) Mitotic phase

Interphase or Resting phase:
- The nucleus of interphase is not in a state of division
- Interphase occurs between every two mitotic phases
- A number of biochemical changes take place in the nucleus, through it appers to be resting
- It involves increase in cell size, synthsis of RNA and proteins
- Protein material and energy pools related to the chromosomal structure and movement ar establishment
- The interphase nucleus is large, dark and prominent
- The duration of interphase is prolonged

Mitotic phase:
- Inter phase is followed by mitotic phase
- Mitotic phase involves **Karyokinesis** and cytokinesis is the division of cytoplasm

Karyokinesis:
- The sequnential changes of karyokinesis are divided into four phases namely prophase, metaphase, anaphase and telophase

1) Prophase:
- Prophase is the first stage of karyokinesis
- During early prophase chromosomes (long, slender) change into short, thick, stout and rod shaped chromosomes by coilong process
- The chromosomal arms appear longitudinally split into chromatids, which are united at the centromere
- During late prophase the nuclear envelop dissolves, nucleolus also disappears and chromosomes are scattered in the cytoplasm

2) Metaphase:
- During metaphse the formation of spindle fibres and orientation of chromosomes on the equator takeplace
- The spindle fibres are made up of microtubules
- The spindle fibres form a bipolar **spindle apparatus**
- The spindle fibres attach to the kinetochore part of the chromosomes and bring them to the equator
- Thus centromeres lie at the equator and form **equatorial plate** or **metaphase plate**
- The chromosomal arms hang to centromere freely and form equatorial plate in the cytoplasm
- The spindle fibres are three types

a) **Continuous fibres**:
- They originate at one pole and extent upto opposite pole without connecting the centromeres

b) **Chromosomal fibres**:
- They originate at one pole and extend upto equator and attach to the centromeres of chromosomes

c) **Interzonal fibres**:
- They are found nearer to equator on the either

3) Anaphase:
- During anaphse spindle fibres show contraction and cause pressure on centromere
- Centromere of each chromosome divides and two chromatids are separated to from the daughter chromosomes
- The spindle fibres pull the daughter chromosomes to opposite poles

4) Telophase:

- The changes occurring in Telophase are reverse to that prophase
- The chromosomes at opposite pole become long and loose their visibility due to despiralization and form chromatin
- The nuclear envelop and nucleoli reappear

Cytokinesis:

- Karyokinesis is followed by cytokinesis (division of cytoplasm)
- At the end of telophase the fragments of spindle fibres (remanents of spindle apparatus) form the 'phagmoplast' at the equator
- The phragmoplast is a barrel shaped structure
- The fluid plat gros centrifugally upto the parent cell walls
- This undergoes physical and chemical changes hemi cellulose are deposited on both the sides of middle lamellum to form two daughter cells
- The divison of cytoplasm is by '**cell plate method**'

Significance of mitosis:

- Mitosis helps in the growth of organisms by increasing the number of cells
- Daughter cells of mitosis are identical to the mother cell in qualitative and qualitative characters, thus genetic integrity of organisms is conserved
- In unicellular organisms mitosis helps only in Reproduction
- It helps in rear and tear mechanism of plant body
- Mitosis helps in wound healing also by regeneration of tissues
- Mitosis is also useful in regeneratin of lost parts and is graftings for vegetative propagation

Meiosis or Reduction Division:

- It occurs in the reproductive cell or germinal cells of sexually reproducing organisms
- The evolution of meiosis is significant in the development of sexual reproduction in plants and animals
- **August Weisman** first observed reduction in the chromosomal number
- Later it was confirmed by **Strasburger** in plants
- The term meiosis was coined by **J.B.Farmer & J.E.More**
- The cells undergoing meiosis are called as **meiocytes**
- Daughter cells show reduce chromosomal number and recombination of genetic traits
- Meiosis is essential to maintain a constant chromosomal number in each species of sexually reproducing organisms
- Fertilization (fusion of gametes) occurs necessary in the sexually reproducing organisms
- Fertilization results in the formation of zygote with double the chromosomal number of gametes
- Zygote is the initial stage of life cycle in the organisms

Significance of meiosis:

- It helps to maintain the constant chromosomal number from one generation to other generation
- Due to crossing over, the genetic recombination causes variations that lead to origin of species and evolution
- It helps in gamete formation during sexual reproduction

Match the following Questions:
Cell Biology
Ex-1

1) Cells were discovered by
2) 1) Hugo von Mohl 2) Purkinje
3) Robert Brown 4) Robert Hooke
3) Free living cells such as bacteria, protozoa were discovered by
1) Robert Hooke 2) Leeuwenhoek
3) Dujardin 4) Rudolf Virchow
4) Rudolf Virchow proposed
1) Cell theory 2) Protoplasmic theory
3) Chromosome theory 4) Cell lineage theory
5) 'Micrographia' was written by
1) Robert Hooke 2) Strasburger 3) Theophrastus 4) Leeuwenhoek
6) The cell theory was credicted to the work of
1) Dujardin 2) Robert Hooke
3) Schleiden & Schwann 4) Sutton & Boveri
7) The term 'Cell' was coined by
1) Schleiden 2) Robert Brown 3) Robert Hooke 4) Leeuwenhoek
8) Bacteria are prokaryotes due to the
1) Presence of cell wall 2) Absence of well organised nucleus
3) Presence of only ribosomes 4) Minute size
9) Single, circular naked coiled DNA molecule of prokayote is
1) Nucleoid 2) Chromosome 3) Heterokaryon 4) Plasmid
10) Most distinguishing feature of plant cell from animal cell is the presence of
1) Chloroplast 2) A large vacuole 3) Dictyosome 4) Cell wall
11) Middle lamellum is chemically
1) Suberin 2) Pectin 3) Chitin 4) Lignin
12) The outermost region of Cell wall is
1) Primary cell 2) Secondary cell
3) Middle lamella 4) Phargmoplast
13) Cell plate which transforms into middle lamellum is secreted by
1) Plasma membrane 2) Golgi complex
3) ER 4) Phragmoplast
14) Thin areas in primary wall are called
1) Pits 2) Primary pit fields 3) Hydathodes 4) Lenticels
15) Frame work of plant cellwall is formed by
1) Cellulose microfibrils 2) MIcrotubules & Microfilaments
3) Mucopeptides 4) Cisternae of Golgi complex
16) Thickness of the cell wall is increased by a process called
1) Intussusception 2) Apposition
3) Agglutination 4) Precipitation
17) Intussusception increases ---- of the cell wall
1) Area 2) Thickness 3) Permeability 4) Precipitation
18) Which cell wall is highly rigid?
1) Suberised wall 2) Lignified wall
3) Cutinised wall 4) Primary wall
19) Viscous fluid of living cell is called "sarcode" by

1) Kollikier 2) Von Mohl 3) Dujardin 4) Purkinje

20) The thing unrelated to protoplasm is
1) Tyndall effect 2) Slightly alkaline
3) Coagulated on heating upto 60^0C 4) Specific gravity is less than one

21) Major component of protoplasm constituting about 85 –90% is
1) Protein 2) Water 3) Enzymes 4) Sugars

22) Outer most living limit of a plant cell is
1) Cell wall 2) Plasma membrane 3) Cytoplasm 4) Tonoplast

23) Plasma membrane is chemically composed of
1) Pectocellulose 2) Proteins
3) Proteins & Photopholids 4) Mucopeptides

24) Trilamellar model or Sandwich model of cell membrane was proposed by
1) Robertson 2) Danielle & Davson
3) Singer & Nicholson 4) Von Mohl

25) Robertson proposed
1) Unit membrane concept 2) Fluid mosaic model
3) Clover leaf model 4) Sol-gel complex model

26) Osmoregulation of the cell is controlled by
1) Cell wall 2) Nucleus 3) Plasma membrane 4) ER

27) ER was reported by
1) Palade 2) Camello Golgi 3) KR Porter 4) Nageli

28) ER extends from
1) Middle lamellum to plasma membrane
2) Tonoplast to plasma membrane
3) Nuclear envelope to plasma membrane
4) Primary wall to secondary wall

29) The differentiation of ER into RER and SER is based on
1) Presence of cisternae 2) Attachment of ribosomes
3) Presence of vescicles 4) Number of cisternae

30) The term ‘Cytoplasm’ was coined by
1) Kolliker 2) KR Porter 3) Nageli 4) Purkinje

31) Extra nuclear portion of protoplasm is called
1) Nuclear envelope 2) Cytoplasm
3) Nucleoplasm 4) Tonoplasm

32) Rotatory movements of cytoplasm is not exhibited by
1) Hydrilla 2) Staminal hair of Rheo discolor
3) Vallisneria 4) Elodea

33) Circulatory movements of cytoplasm are seen in the
1) Staminal hair cells of Rhoeo 2) Leaf cells of Hydrilla
3) Cells of onion pealing 4) Pith cells

34) Cell organelles considered as the most primitive are
1) Lysosomes 2) Ribosomes 3) Vacuoles 4) Mitochondria

35) Universal cell organelles found in all living cells are
1) Ribosomes 2) Plastids 3) Mitochondria 4) Vacuoles

36) Ribosomes were discovered by
1) Porter 2) Benda 3) Palade 4) Schimper

37) Ribosomes are made up of
1) Lipids & Proteins 2) RNA & Proteins
3) DNA, RNA & Proteins 4) Proteins & Carbohydrates

38) Membraneless cell organelles are
1) Ribosomes 2) Nucleosomes 3) Lysosomes 4) Peroxisomes
39) Diameter of ribosomes is
1) $23A^0$ 2) 20nm 3) $230A^0$ 4) 70S
40) Protein synthesis takes place on the surface of
1) Mitochondria 2) SER 3) Ribosomes 4) Golgi complex
41) Ribosomal subunits are held together at the time of translation in the presence of
1) Mg^{2+} 2) Ca^{2+} 3) K^+ 4) Na^+
42) In Eukaryotes, 80S ribosomes are synthesized in
1) Nucleolus 2) Mitochondria 3) Chloroplasts 4) Ergosomes
43) 70S ribosomes split up into two sub units which are
1) 50S and 30S 2) 30S and 40S
3) 35S and 35S 4) 60S and 40S
44) A linear array of ribosomes translating the message in the same mRNA is called
1) Microsomes 2) Ergastosomes 3) Polysomes 4) Achrosomes
45) Enzyme found in Ribosomes which is essential for peptide bond formation is
1) Aminoacyl tRNA synthetase 2) Peptidyl transferase
3) RNA polymerase 4) Peptidyl hydrolase
46) Lipochondria, Idiosomes are the alternative names of this cell organelle
1) Mitochondria 2) Lysosomes 3) Golgi complex 4) Elaeioplasts
47) Functional units of Golgi complex are called
1) Dictyosomes 2) Cisternae 3) Vescicles 4) Idiosomes
48) Cell organelle that secretes insulin is
1) SER 2) RER 3) Golgi complex 4) Idiosomes
49) These are regarded as protein factories
1) Golgi complex 2) Ribosomes 3) Nucleoli 4) Phagocytosis
50) Main function of Golgi complex is
1) Digestion 2) Secretion 3) Excretion 4) Phagocytosis
51) Cell wall materials, membrane materials are synthesized in
1) Lomasomes 2) Chitosomes 3) Golgicomplex 4) ER
52) Seat of origin of lysosomes is
1) SER 2) RER 3) Golgi complex 4) Leucoplasts
53) Thalakoids are the components of
1) Golgi complex 2) Chloroplast 3) Mitochondria 4) ER
54) The type of plastids found commonly in unexposed cells is
1) Leucoplasts 2) Chloroplasts 3) Chromoplasts 4) Rhodoplasts
55) Plastids were first reported by
1) Schimper 2) Sachs 3) Leewenhoek 4) Benda
56) Colourless plastids concerned with the storage of reserve food are
1) Elaeioplasts 2) Leucoplasts 3) Chromoplasts 4) Chloroplasts
57) Plastids found in roots of Taeniophyllum are
1) Chromoplasts 2) Chloroplasts 3) Leucoplasts 4) Elaeioplasts
58) Plastids are found in
1) Bacteria 2) Fungi 3) Animals 4) Plants
59) Roots of carrot have
1) Xanthophyll 2) Carotene 3) Chlorophyll 4) Anthocyanin
60) The ripe fruits of tomato have
1) Xanthophyll 2) Carotene 3) Chlorophyll 4) Anthocyanin
61) Fucoxanthin is found in

1) Red algae 2) Brown algae 3) Blue green algae 4) Green algae

62) Phycocyanin is found in
1) Brown algae 2) Blue green algae
3) Green algae 4) Fungi

63) Phycoerythrin is found in
1) Brown algae 2) Red algae
3) Green algae 4) Fungi

64) The plastids concerned with assimilatory function are
1) Chromatophores 2) Chloroplasts
3) Chromoplasts 4) Leucoplasts

65) A stack of thylakoids of chloroplast is called
1) Stroma 2) Granum 3) Matrix 4) Cisternae

66) Photosynthetic pigments are present in the
1) Lumen of thylakoid 2) Membranes of thylakoids
3) Stroma 4) Cristae

67) Dark reaction of photosynthesis occurs in
1) Stroma 2) Thylakoid 3) Granum 4) Cristae

68) Light reaction of photosynthesis occurs in
1) Stroma 2) Nucleus 3) Grana of chloroplast 4) Cristae

69) Which of the following cell organelles have DNA?
1) Chloroplast and bioblast 2) ER and Golgi complex
3) Ribosome and Dictyosome 4) Spherosome & Iysosome

70) Semiautonomous cell organelles found in autotrophs only
1) Mitochondria 2) Lysosomes
3) Chloroplasts 4) Ribosomes

71) The term plastid was proposed by
1) Leeuwenhoek 2) Altmann 3) Schimper 4) Perner

72) Potential energy is converted into kinetic energy in
1) Chloroplast 2) Nucleus 3) Mitochondria4) Ribosomes

73) Mitochondria were first discovered by
1) Altmann 2) Kolliker 3) Benda 4) Schimper

74) The term bioblast was proposed by
1) Altmann 2) Benda 3) Kollicker 4) Strasburger

75) The term “mitochondrion” was given by
1) Benda 2) Altmann 3) Strasburger 4) Kollicker

76) Oxisomes or F_1 particles are found on
1) Thylakoids 2) Cisternae 3) Vesicles 4) Cristae

77) In Mitochondria, Krebs cycle occurs in the
1) Cristae 2) Oxysomes 3) Matrix 4) Membrane

78) In Mitochondria electron transport occurs in the
1) Cristae 2) Matrix 3) Ribosome 4) All the above

79) More Mitochondria would be found in
1) Meristematic cells 2) Epidermis
3) Companion cells 4) Xylem parenchyma

80) Mitochondria are present in all cells except
1) Fungi 2) Bacteria and blue green algae
3) Algae 4) Angiosperms

81) The number of vacuoles found in a cell showing rotatory movement of cytoplasm is
1) One 2) Two 3) Three 4) Four

82) Dilute aqueous solution found in vacuole is called
1) Nuclear sap 2) Cytoplasm
3) Cell sap 4) Latex
83) An old living cell is characterized by
1) Absence of vacuole 2) Presence of two nuclei
3) Absence of nucleus 4) Presence of large vacuole
84) Tonoplast is present around
1) Vacuole 2) Nucleus 3) Ribosome 4) Lysosome
85) Vacuole is not concerned with
1) Osmoregulation 2) Assimilation
3) Turgidity of cell 4) Storage of materials
86) Repository of cell is
1) Mitochondria 2) Chloroplast 3) Lysosome 4) Vacuole
87) Hydrolytic enzymes abundant in
1) Chloroplasts 2) Mitochondria 3) Lysosomes 4) Vacuoles
88) Lysosomes are abundantly found in
1) RBC 2) Excretory cells 3) Secretory cells 4) Digestive cells
89) Suicidal bags of a cell were discovered by
1) De Duve 2) Fontana 3) Palade 4) Golgi
90) Lysosomes are formed from
1) Mitochondria 2) Dictyosomes
3) Ribosomes 4) Spherosomes
91) Lysosomes originate from
1) Golgi complex 2) ER or Nuclear envelope
3) ER or cell membrane 4) Any of the above
92) Double membranes absent in
1) Chloroplast 2) Mitochondria 3) Nucleus 4) Lysosome
93) Microtubules and micro filaments were reported by
1) De Robertis and Frenchi 2) Singer and Nicholson
3) Davson and Danielli 4) Sutton and Boveri
94) Spindle fibres are made up of
1) Tubulin 2) Myosin 3) Actin 4) Pilin
95) Peroxisomes are mainly concerned with
1) Respiration 2) Photosynthesis
3) Photorespiration 4) Photolysis
96) Conversion of fats into carbohydrates is carried out by
1) Lysosomes 2) Peroxisomes
3) Sphaerosomes 4) Glyoxysomes
97) Self assembling polymers are
1) Cisternae 2) Thylakoids 3) Microtubules 4) Ribosomal sub-units
98) Peroxisomes are involved in
1) Degradation of H_2O_2 2) Oxidation of fatty acids
3) Synthesis of phospholipids 4) All
99) Conversion of fats into carbohydrates is a part of
1) HMP path 2) Glycoxylate cycle 3) EMP path 4) DCA cycle
100) Organelles concerned with storage of fats
1) Lipochondria 2) Glycoxylate cycle
3) Sphaerosomes 4) All
101) Which of the following is insoluble in water

1) Glycogen 2) Maltose 3) Verbascose 4) Sedoheptulose

101) Which of the following is heteropolymer?
1) Hemicellulose 2) Cellulose 3) Glycogen 4) None

102) Identify the homogenous combination among the following
1) Glucose, GAP, Sucrose 2) Arabinose, Galactose, Erythrose
3) Ribose, Xylulose, Arabinose 4) Raffinose, Maltose, Fructose

103) An example for compound carbohydrate
1) Gums 2) Mucilages 3) Tanin 4) All

104) An example for trioses
1) Sedoheptulose 2) Erythrose phosphate
3) Glyeraldehyde phosphate 4) Glucose

105) An example for tetroses
1) Glyceraldehyde phosphate 2) Erythrose phosphate
3) Ribose 4) Glucose

106) Which is not a hexose?
1) Glucose 2) Fructose 3) Galactose 4) Sedoheptulose

107) An example for heptose
1) Glyceraldehyde phosphate 2) Erythrose phosphate
3) Glucose 4) Sedoleptulose

108) 12Carbon Oligosaccharides are
1) Sucrose & maltose 2) Raffinose & maltose
3) Stachyose & Raffinose 4) Verbascose & Sucrose

109) Which of the following is not a polysaccharide?
1) Cellulose 2) Hemicellulose
3) Glycogen 4) Glucose

110) Which of the following is a polysaccharide?
1) Starch 2) Pectin 3) Inulin 4) All the above

111) Which one is not a polysaccharide?
1) Starch 2) Cellulose 3) Stachyose 4) Inulin

112) Which of the following is non secretary product?
1) Enzymes 2) Nector 3) Xanthophyll 4) Alkaloids

113) From which part of Papaver, morphine is obtained?
1) Latex of roots 2) Latex from unripe fruits
3) Xylem sap 4) Phloem sap

114) Betel plant belongs to this genus
1) Hyphaene 2) Areca 3) Piper4) Sapindus

115) Quinine is obtained from the
1) Bark of Cinchona 2) Root of Rauwolfia
3) Seeds of Coffea 4) Leaves of Datura

116) Which part of Nicotiana yields nicotine?
1) Old leaves2) Root 3) Fruit 4) Seed

117) Which part of Datura yields atropine?
1) Seed 2) Fruit 3) Leaves 4) Root

118) Rubber is prepared from
1) Reisins 2) Tannisn 3) Latex 4) Organic acids

119) Which one of the following is made up of hard non living material?
1) Plasma membrane 2) Nuclear envelope
3) ER 4) Cell wall

120) Which of the following is referred to as dynamic center of the cell or master

organelle or cell brain?
1) Nucleus 2) Nucleolus 3) Chromosomes 4) DNA

121) Two nuclei are found in the cells of
1) Rhizopus 2) Vaucheria 3) Acetabularia 4) Tapetal cells

122) A nuclear stain is
1) Methylene blue 2) Eosine 3) Acetocarmine 4) Haematoxylin

123) Mature sieve elements are
1) Enucleate 2) Monokaryotic 3) Dikaryotic 4) Coenocytic

124) Fibrillar zone and granular zone are found in
1) Vacuole 2) Nucleolus 3) Ribosomes 4) Cell wall

125) Various life activities of a cell are coordinated by
1) Nucleolus 2) Nucleus 3) Protoplasm 4) ER

126) Contact between nucleoplasm and cytoplasm is established through
1) Pits 2) Plasmodesmata 3) Nuclear pores 4) ER

127) Heterocromatic masses found in the interphase nucleus are called
1) False nuclei 2) Plasmosomes
3) Karyosomes 4) Kinomeres

128) Fibrillar and granular zones are found in the
1) Centrosome 2) Plasmosome 3) Karyosome 4) Episome

129) Nucleolus is associated with
1) Nuclear envelope 2) Heterochromatic zone
3) Sec. constriction 4) Kinetochore

130) Seat of production of ribosomes is
1) Rough ER 2) Polysome 3) Karyolymph 4) Nucleolus

131) RNA, proteins and DNA are found in
1) Nucleolus 2) Chromosomes 3) Ribosomes 4) 1 & 2

132) Chromosomes theory of inheritance was proposed by
1) Schleiden and Schwann 2) Beadle and Tatum
3) Sutton and Boveri 4) Jacob and Monod

133) Chromosome are the
1) Physical basis of heredity 2) Physical basis of life
3) Chemical basis of heredity 4) Dynamic center of the cell

134) Longest metaphase chromosome is found in
1) Ophioglossum 2) Trillium 3) Lilium 4) Haplopappus

135) The following bears lowest number of chromosomes in its somatic cells
1) Ophioglossum 2) Haplopapaus 3) Microsterias 4) Bracheomonas

136) Diagramatic representation of Karyotype is called
1) Picogram 2) Idiogram 3) Hologram 4) Heiroglyphics

137) Chromosomes can be best observed in
1) Anaphase 2) Diplotene 3) Prophase 4) Metaphase

138) The loose and easily separable coilings of chromatids are called
1) Plectonemic 2) Paranemic 3) Polynemic 4) Binemic

139) Ends of chromosomes exhibiting polarity and offering stability are known as
1) Knobs 2) Chromomeres 3) Satellites 4) Telomeres

140) Bead like swellings formed along the length of prochromosomes of early prophase are called
1) Centromeres 2) Metameres 3) Chromomeres 4) Kinomere

141) The part of chromatid arm beyond secondary constriction is called
1) Satellite or Trebent 2) Centromere or Kinetochore

3) Nucleolar organizer 4) Balbianiring

142) Common type of chromosomes are
1) Telocentric 2) Monocentric 3) Holocentric 4) Acentric

143) Telocentric chromosome is
1) With telomere 2) Without telomore
3) With terminal centromore 4) With trebent

144) J-shaped anaphase chromosome is
1) Acrocentric 2) Acentric 3) Holocentric 4) Submetacentric

145) Definitive nucleus is cytologically
1) Haploid 2) Diploid 3) Polypolid 4) Triploid

146) Plant having 2n =24
1) Oryza 2) Gossypium 3) Zea 4) Tobacco

147) A pair of genes determining a character is called
1) Genome 2) Alleles 3) Bivalent 4) Karyotype

148) Chromosomes are made up of
1) DNA and RNA 2) RNA and Proteins
3) DNA and Proteins 4) Only DNA

149) Proteins essential for the formation of chromation is
1) Histones 2) Actin 3) Tubulin 4) Myosin

150) Centromere is not called
1) Primary constriction 2) Kinetochore
3) Kinomere 4) Karyosome

151) Chromosome having trebent is called
1) Nucleolar organizer 2) Acentric chromosome
3) SAT chromosome 4) Acrocentric chromosome

152) Best one to count chromosome is
1) Prophase 2) Metaphase 3) Diakinesis 4) Anaphase

153) Allosomes are
1) Sex chromosomes 2) Giant chromosomes
3) Super numerary chromosomes 4) Other than Sex chromosomes

154) Chromatid represents
1) A complete chromosome 2) Half of the chromosome
3) A pair of chromosomes 4) One genome

155) In this chromosome, centromere is subterminal
1) Telocentric 2) Acrocentric 3) Submetacentric 4) Acentric

156) Chromosomes are connected directly with
1) Heredity 2) Translation 3) Respiration 4) None

157) Chromatids remain attached at
1) Centromere 2) Telomere
3) Throughout their length 4) Both Priamry and Secondary constrictions

158) Nucleolar organizer region is rich in
1) rRNA 2) rRNA genes 3) rDNA genes 4) Ribosomes

159) Centromere is concerned with
1) Splitting of chromosome 2) Movement of chromosome to poles
3) Attachment of spindle fibres 4) 2 & 3

160) If aleurone layer of a plant has 42 chromosomes its perisperm has
1) 212) 28 3) 84 4) 42

161) Shape of Acrocentric chromosome in Anaphase
1) V-shape 2) L-shape 3) J-shape 4) I-shape

162) Size of chromosome can be measured in
1) Metaphase 2) Anaphase 3) Telophase 4) Interphase
163) Shape of the bacterial chromosome is
1) Linear 2) Ring 3) Rod 4) X-shaped
164) V-Shaped anaphasic chromosome is
1) Metacentric 2) Sub-metacentric 3) Acrocentric 4) Telocentric
165) Which one exhibits polarity in chromosome
1) Telomere 2) Centromere 3) Trebent 4) Chromatin
166) Chemical basis of heredity is
1) Protoplasm 2) Nucleus 3) Chromosome 4) DNA
167) Chemical analysis of DNA was given by
1) Watson & Crick 2) Wilkins & Franklin
3) Hershey & Chase 4) Chargaff
168) Double helix model of DNA was given by
1) Watson & Crick 2) Wilkins & Franklin
3) Hershey & Chase 4) Chargaff & Pauling
169) False thing with regard to DNA
1) Diameter is 20A0 2) Stands are quite complementary but antiparllel
3) Stands coil around each other clockwisely
4) Strands are held together by H-bonds
170) Rungs in DNA are
1) Sugar-phosphate chains 2) N_2 base pairs
3) Sugar –N_2 base 4) N_2 base and phosphate radicals
171) Sugar –phosphate chains in DNA act as
1) Back bones 2) Steps 3) Axis 4) Polynucleotide strands
172) Purins are
1) Monocyclic and homocyclic 2) Monocyclic and heterocyclic
3) Dicyclic and homocyclic 4) Dicyclic and heterocyclic
173) Pyrimidines in DNA are
1) A and G 2) T and C 3) A and T 4) G and C
174) Building blocks of DNA consists of
1) Purins and pyrimidines 2) Sugar – phosphate chains
3) Sugar + N_2 bases 4) Sugar + N_2 base +phosphate
175) Nucleotide differs from nucleoside in
1) Having phosphate 2) Lacking phosphate
3) Lacking N_2 base 4) Having sugar
176) Formula of sugar in DNA is
1) $C_5H_{10}O_5$ 2) $C_6H_{12}O_6$ 3) $C_5H_{10}O_4$ 4) $C_{10}H_{20}O_8$
177) Bond between the following is an ester bond
1) Sugar and Phosphate 2) Sugar and N_2 base
3) Nucleotides of opposite strands 4) N_2 base and phosphate
178) Two strands of DNA are held together by
1) Glycosidic bonds 2) H-bonds
3) Diester bonds 4) All bonds
179) Angle between successive pairs of nucleotides in DNA is
1) $34A^0$ 2) $3.4A^0$ 3) 36^0 4) $36A^0$
180) Number of nucleotides in one coil of DNA
1) 10 2) 20 3) 20pairs 4) 34
181) What is untrue about DNA?

1) Denatures at 70^0C 2) Absorption spectrum is 260nm
3) Denatured at high pH 4) It is the genetic material in all organisms

182) Single stranded DNA is found in
1) α phage 2) T_2 phage 3) ϕ x 174 coli phage 4) Rod virus

183) DNA replicates by ----- method
1) Conservative 2) Semi conservative
3) Non conservative 4) Terminism

184) Semi conservative method of DNA replication was proved to be correct by
1) Watson & Crick 2) Hershey & Chase
3) Messelson & Stahl 4) Temin & Baltimore

185) DNA replication occurs during
1) S-period 2) Metaphase 3) Anaphase 4) Interphase

186) Self replication of DNA is called
1) Heterocatalysis 2) Autocatalysis
3) Terminism 4) Transcription

187) DNA replication is catalysed by
1) Transcriptase 2) Reverse transcrytase
3) DNA polymerase 4) Endocatalysis

188) Formation of mRNA from DNA is
1) Transcription 2) Teminsim 3) Translation 4) Autocatalysis

189) DNA acts as template for the synthesis of
1) Only RNA 2) Only DNA 3) Proteins 4) Both DNA & RNA

190) RNA is mainly concentrated in
1) Nucleus 2) Mitochondria 3) Plastids 4) Ribosomes

191) RNA can act as genetic material in
1) All viruses 2) All plants viruses
3) All animal viruses 4) RNA viruses

192) N_2 base found in RNA and absent in DNA is
1) Adenine 2) Thymine 3) Uracil 4) Cytosine

193) RNA that brings message regarding protein synthesis is
1) rRNA 2) tRNA 3) sRNA 4) mRNA

194) mRNA was discovered by
1) Watson & Crick 2) Ochoa & Nirenberg
3) Jacob & Monad 4) Hershey & Chase

195) In prokaryotes half life period of mRNA is
1) 2 minutes 2) 4 hours 3) Infinity 4) 2 days

196) Genetic message is found in mRNA in the form of
1) Anticodons 2) Replicons 3) Transposans 4) Codons

197) The following is the usual initiating codon
1) AUG 2) GUG 3) UAG 4) CCA

198) The unstable one is
1) ssDNA 2) dsRNA 3) mRNA 4) tRNA

199) RNA which is almost in the form of a regular double helix
1) rRNA 2) mRNA 3) dsRNA 4) tRNA

200) Smallest nongenetic RNA is
1) mRNAs 2) tRNA 3) Viral RNAS 4) rRNA

201) tRNA constitutes about -----of the total RNA
1) 15% 2) 75-80% 3) 5-10% 4) 2%

202) Clover leaf model of tRNA was proposed by

1) James Boner 2) R.Holley 3) S.Ochoa 4) P.C.Zamecnik

203) Triplet of unpaired nucleotides at 3' end of tRNA
1) AUG 2) GUG 3) CCA 4) UAA

204) tRNA identifies genetic message of mRNA by its
1) CCA end 2) Anticodon 3) Extra loop 4) D-loop

205) tRNA cannot be called
1) sRNA 2) Adaptor RNA
3) Interpreter of genetic code 4) Tenaceously bound RNA

206) The following helps in bringing aminoacids into ribosomes during protein synthesis
1) tbRNA 2) tRNA
3) Aminoacyl to tRNA synthetase 4) Peptidyl transferase

207) Kinds of monocyclic N2 bases in nucleic acids are
1) Four 2) Five 3) Three 4) Two

208) Pyrmidine common to DNA and RNA is
1) A 2) T 3) U 4) C

209) Length of DNA is
1) $20A^0$ 2) $34A^0$ 3) Variable 4) Small in all organisms

210) Left handed coiled DNA is
1) Z-DNA 2) B-DNA 3) A-DNA 4) C-DNA

211) The distance between two Nitrogen base pairs of DNA molecule
1) $34A^0$ 2) $6.4A^0$ 3) $4.3A^0$ 4) $3.4A^0$

212) The term "Mitosis" was coined by
1) Strasburger 2) Farmer and Moore
3) Walter Fleming 4) Rudolf Virchow

213) Mitosis occurs commonly in
1) Pollen grains 2) Spore mother cells
3) Vegetative cells 4) Xylem vessels

214) Best place in plant to observe mitosis
1) Anther 2) Root apex 3) Stem apex 4) Cambium

215) DNA replication occurs in
1) G_1 phase 2) G_2 phase 3) M-phase 4) S-phase

216) In meristematic cells, interphase occurs
1) Initially 2) Terminally
3) Between successive divisions 4) Permanently

217) With regard to biochemical activities which is very active?
1) Anaphase 2) Interphase 3) Cytokinesis 4) Metaphase

218) Anastral Mitosis is characteristic of
1) Higher animals 2) Lower animals
3) Higher plants 4) all organisms

219) Spindle fibres are made up of
1) Cellulose 2) Proteins 3) Lipids 4) Pectin

220) Equatorial plate
1) A fluid plate 2) Cell plate
3) Chromosomes arranged as plate 4) Phragmoplast

221) Centromeric division occurs during
1) Prophase 2) Metaphase 3) Anaphase 4) Interphase

222) Shortest phase
1) Interphase 2) Metaphase 3) Anaphase 4) Telophase

223) Daughter nuclei are reorganised in this phase

1) Interphase 2) Prophase 3) Metaphase 4) Telophase

224) Phragmoplast is related to
1) Cell elongation 2) Cytokinesis
3) Assemblage of chromosomes at metaphase plate 4) Division of nucleus

225) Material of cell plate is synthesised by
1) Phragmoplast 2) Protoplast 3) Golgi complex 4) Nucleus

226) Growth of cell plate is
1) Centripetally 2) Centrifugally 3) Acentrically 4) Concentrically

227) Which one is not possible due to mitosis?
1) Wound healing 2) Regeneration
3) Grafting 4) Reduction of Chromosome number

228) The phase which is genetically most inactive
1) Anaphase 2) Interphase 3) Metaphase 4) Telophase

229) Despiralisation takes place during
1) Prophase 2) Metaphase 3) Anaphase 4) Telophase

230) Reduction of chromosome number was first identified by
1) Strasburger 2) August Weisman
3) J.B.Farmer and J.E.Moore 4) Walter Flemming

231) The term "meiosis" was coined by
1) Walter Flemming 2) Strasburger
3) J.B.Summer & Moore 4) J.B.Farmer and J.E.Moore

232) In plants, meiosis was discovered by
1) Farmer and Moore 2) Strasburger
3) Weismann 4) Virchow

233) Cell that undergoes meiosis is
1) Meiocyte 2) Endocyte 3) Mitocyte 4) Oocyte

234) Meiocyte in thallophytes (Lower plants) is
1) Zygote 2) Spore mother cell
3) Gamete mother cell 4) Archesporial cell

235) In Plants, meiosis occurs in
1) Roots 2) Leaves 3) Stems 4) Anthes & Ovules

236) Best structure in plants to observe meiosis
1) Root apex 2) Zygote 3) Anther 4) Ovule

237) The number of chromosomes is halved during
1) Mitosis 2) Meiosis 3) Amitosis 4) Endomitosis

238) Prolonged initial interphase is seen in
1) Permanent cell 2) Meristematic cell
3) Meiocyte 4) Zygote of higher plants

239) "Boquest stage" in meiosis is seen at
1) Leptotene 2) Zygotene 3) Pachytene 4) Diplotene

240) Pairing of homologous chromosomes occurs in
1) Leptotene 2) Zygotene 3) Pachytene 4) Diplotene

241) Selective pairing of homologous chromosomes results in the formation of
1) Bivalents 2) Synapsis 3) Chaismata 4) Heterokaryon

242) Selective pairing of homologous chromosomes is called
1) Synapsis 2) Disjunction 3) Plasmogamy 4) Desynapsis

243) Pairing of homologous chromosomes initiated simultaneously at more places
1) Proterminal synapsis 2) Procentric synapsis
3) Random synapsis 4) Linkage

244) Exchange of chromatin between non-sister chromatids is called
1) Linkage 2) Crossing over 3) Diakinesis 4) Disjunction
245) Crossing over occurs during
1) Leptotene 2) Zygotene 3) Pachytene 4) Diplotene
246) Crossing over occurs at
1) Two strand stage 2) 3 strand stage
3) Four strand stage 4) 1 strand stage
247) Enzymes help in crossing over
1) Endonuclease and ligase 2) Restriction endonuclease and ligase
3) Endonuclease and Exonuclease 4) Polymerase and Endonuclease
248) Crossing over results in
1) Recombination of non linked genes 2) Recombination of linked genes
3) Deletion of genes 4) Addition of genes
249) Chaismata clearly visible in
1) Pachytne 2) Diplotene 3) Diakinesis 4) Anaphase-I
250) Displacement of intermediary chaismata to poles is called
1) Terminalisation 2) Translocation 3) Synapsis 4) Transcription
251) Best phase to count chromosomes
1) Metaphase 2) Diakinesis 3) Zygotene 4) Anaphase –II
252) Bivalents are oriented at equatorial plane during
1) Metaphase 2) Metaphase –I 3) Metaphase –II 4) Diakinesis
253) Movement of homologous chromosomes of bivalent of opposite poles is equal
1) Disjunction 2) Crossing over 3) Terminalisation 4) Synapsis
254) Disjunction of homologous chromosomes occurs in
1) Metaphase –I 2) Diakinesis 3) Anaphase –I 4) Telephase –I
255) Genomes migrate to opposite poles by the end of
1) Anaphase –I 2) Telophase –I 3) Diakinesis 4) Cytokinesis
256) Daughter nuclei formed by the end of telophase I are
1) Diploid 2) Haploid 3) Polyploid 4) Ploidy not known
257) Total number of spindles formed in Meiocyte
1) 1 2) 2 3) 3 4) 4
258) Main significance of Meiosis is
1) Maintanance of constant chromosome number
2) Maintanance of Genetic continuity and equality
3) Recombination of Genes
4) Formation of gametes
259) Number of meiotic divisions necessary to from 50 pollen grains
1) 12 2) 13 3) 100 4) 125

Keys

1)4	2)2	3)4	4)1	5)3	6)3	7)1	8)1	9)4	10)2
11)3	12)2	13)2	14)1	15)2	16)1	17)2	18)3	19)4	20)2
21)2	22)3	23)2	24)1	25)3	26)3	27)3	28)2	29)1	30)2
31)2	32)1	33)2	34)1	35)3	36)2	37)1	38)3	39)3	40)1
41)1	42)1	43)3	44)2	45)3	46)1	47)3	48)2	49)2	50)3
51)3	52)2	53)1	54)3	55)2	56)2	57)4	58)2	59)2	60)2
61)2	62)2	63)2	64)2	65)2	66)1	67)3	68)1	69)3	70)3
71)3	72)2	73)1	74)1	75)4	76)3	77)1	78)1	79)2	80)1

81)3	82)4	83)1	84)2	85)4	86)3	87)4	88)1	89)2	90)1
91)4	92)1	93)1	94)3	95)4	96)3	97)4	98)2	99)4	100)1
101)4	102)3	103)4	104)3	105)2	106)4	107)4	108)1	109)4	110)4
111)3	112)4	113)2	114)3	115)1	116)1	117)3	118)3	119)4	120)1
121)4	122)4	123)1	124)2	125)2	126)3	127)3	128)2	129)3	130)4
131)1	132)3	133)1	134)2	135)2	136)2	137)4	138)2	139)4	140)3
141)1	142)2	143)3	144)1	145)2	146)1	147)2	148)3	149)1	150)4
151)3	152)3	153)1	154)2	155)2	156)1	157)1	158)2	159)4	160)2
161)3	162)1	163)2	164)1	165)1	166)4	167)4	168)1	169)3	170)2
171)1	172)4	173)2	174)4	175)1	176)3	177)1	178)2	179)3	180)2
181)4	182)3	183)2	184)3	185)1	186)2	187)3	188)1	189)4	190)4
191)4	192)3	193)4	194)3	195)1	196)4	197)1	198)3	199)3	200)2
201)1	202)2	203)3	204)2	205)4	206)2	207)3	208)4	209)3	210)1
211)4	212)3	213)3	214)2	215)4	216)3	217)2	218)3	219)2	220)3
221)3	222)3	223)4	224)2	225)3	226)2	227)4	228)3	229)4	230)2
231)4	232)2	233)1	234)1	235)4	236)3	237)2	238)3	239)1	240)2
241)1	242)1	243)3	244)2	245)3	246)3	247)1	248)2	249)2	250)1
251)2	252)2	253)1	254)3	255)1	256)2	257)3	258)1	259)2	

Ex-2

1) Study the following series

Cell Organelle	Scientist	Function
I) Microtubules	deRobertis & Frenchi	Spindle fibres
II) Lysosomes	Christian de Duve	Autolysis of cell
III) Perioxisomes	Rhodin	Photophorphorylation
IV) Glyoxysomes	Bridenbach	Calvin cycle

Which two are correct?

1) I and II 2) II and III 3) III and IV 4) I and IV

2) Study the following table

Scientist	Organelle	Function
I) Kolliker	Mitochondria	Biofurnace
II) de Duve	Lysosomes	Oxidation of fatty acids
III) Palade	Ergosomes	Protein synthesis
IV) Fontana	Plasmosomes	Lipid metabolism

Which two combinations are correct?

1) I and III 2) II and IV 3) I and IV 4) III and IV

3) Study the following table

List –I	List –II
A) M.J.Schleiden & T.Schwann	I) Chromosome theory
B) Sutton & Bovery	II) Cell theory
C) Max schultz	III) Cell lineage theory
D) Ruldolf virchow	IV) Laws of inheritance
	V) Protoplasm theory

The correct match is

1) A-II, B-I, C-V, D-III 2) A-I, B-V, C-III, D-IV
3) A-V, B-II, C-I, D-III 4) A-IV, B-III, C-II, D-I

4) Study the following lists

List –I	List –II
A) Phycoerythrin B) Phycocyanin C) Fucoxanthin D) Lycopene	I) Blue green algae II) Brown algae III) Tomato IV) red algae V) Green algae

1) A-I, B-III, C-V, D-II 2) A-II, B-V, C-IV, D-I
3) A-IV, B-I, C-II, D-III 4) A-III, B-II, C-I, D-II

5) Study the following lists:

List –I	List –II
A) Spindle fibres B) Autolysis C) Photopholipids D) Cellulose	I) Peroxisomes II) Golgicomplex III) Mitochondria IV) Lysosomes V) Microtubules

1) A-III, B-II, C-I, D-IV 2) A-V, B-IV, C-II, D-III
3) A-IV, B-III, C-V, D-I 4) A-V,B-IV, C-I, D-II

6) Study the following lists:

List –I	List –II
A) Repository of cell B) Cell with in a cell C) Primitive cell organelle D) Master organelle	I) Nucleus II) Ribosomes III) Peroxisomes IV) Chloroplasts V) Vacuole

1) A-V, B-IV, C-II, D-I 2) A-IV, B-II, C-III, D-V
3) A-V, B-IV, C-I, D-II 4) A-I, B-V, C-III, D-II

7) Study the following lists:

List –I	List –II
A) Elodea B) Ascomycetes C) Vaucheria D) Rheo discolor	I) Circulation II) Coenocytic III) Photorespiration IV) Dikaryotic V) Rotation

1) A-III, B-I, C-II, D-IV 2) A-V, B-IV, C-I, D-II
3) A-I, B-V, C-III, D-II 4) A-II, B-I, C-IV, D-V

8) Study the following lists:

List –I	List –II
A) Peptidyl transferase B) Anthocyanin pigments C) Break down of H_2O_2 D) Convertion of fats into carbohydrates	I) Glycoxisomes II) Ribosomes III) Lysosomes IV) Vacuoles V) Peroxisomes

1) A-IV, B-V, C-III, D-II 2) A-III, B-II, C-I, D-IV
3) A-I, B-III, C-V, D-I4) A-II, B-IV, C-V, D-I

9) Study the following lists:

List –I	List –II
A) Rhodin	I) Microtubules

B) K.R.Porter C) de Rebortis & Frenchi D) Robertson	II) Unit membrane III) Mitochondria IV) Peroxisomes V) Endoplasmic reticulum

1) A-I, B-II, C-III, D-V 2) A-V, B-I, C-III, D-IV
3) A-IV, B-V, C-I, D-II 4) A-II, B-III, C-I, D-IV

10) Study the following lists:

List –I	List –II
A) Physical basis of heredity B) Physical basis of life C) Chemical basis of heredity D) Sucidial bags of the call	I) Lysosomes II) DNA III) Protoplasm IV) Dictysomes V) Chromosomes

1) A-V, B-III, C-II, D-I 2) A-IV, B-III, C-II, D-V
3) A-III, B-IV, C-V, D-II 4) A-I, B-II, C-III, C-V

11) Carotenoids are found in
I) Chloroplasts II) Chromoplasts
III) Chromatophores IV) Vacuble
1) I and II are correct 2) II and III are correct
3) III and IV are correct 4) I and IV are correct

12) Structures responsible for intracellular transport of materials
I) E.RII) Glogicomplex III) Peroxisomes IV) Cytoskeleton
1) I & II are correct 2) II & III are correct
3) III & I are correct 4) IV & I are correct

13) Nucleoid controls and co-ordiantes cellular activities in
I) Red algae II) Blue-green algae III) Bacteria IV) Brown algae
1) II & III are correct 2) III & IV are correct
3) IV & I are correct 4) II & IV are correct

14) Assertion: Protoplasm is called “the physical basis of life”
Reason: Hollow compartment like structures in cork tissue were the first discovered cells
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

15) Assertion: Nature of protoplasm was interpreted as colloidal material
Reason: Brownian movement and Tyndall effect are shown by protoplasm
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

16) Assertion: Both clockwise and anticlockwise streaming of cytoplasm can be observed in the staminal hair cells of Elodea
Reason: Abundant organic substance in cytoplasm is proteins
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

17) Assertion: Endoplasmic reticulum consists of cisternae, sacs and tubules

Reason: E.R is a polymorphic cell organelle
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

18) Assertion: Ribosomes are considered as primitive cell organelles
Reason: They are found in prokaryotes also
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

19) Assertion: Biogenesis of ribosomes is carried out by plasmosomes
Reason: 70s type of ribosomes are found in prokaryotes
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

20) Assertion: Amino acids are joined by peptide bonds
Reason: Peptidases are found in the larger sub unit of Ribosomes
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

21) Assertion: Green chillies turn red when ripe
Reason: Plastids are interconvertible
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

22) Assertion: Chloroplasts and mitochondria contain their own genetic material
Reason: They are considered as semi-autonomous cell organelles
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

23) Assertion: Phosphorylation occurs in both chloroplasts and mitochondria
Reason: Cytochromes which help in electron transport are found in both chloroplasts and mitochondria
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

24) Assertion: Spindle apparatus is not formed in bacterial cell division
Reason: Microtubules are absent in bacteria
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

25) Assertion: Mitochondria, Lysosomes and Ribosomes are abundant in meristematic cells

Reason: Lysosomes are called ‘suicidal bags’
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

26) Assertion: In the mesophyll cells of C_3 plants amino acids like glycine and serine are synthesized during day time
Reason: Glyoxylate cycle is carried out by peroxisomes
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

27) Assertion: Multiple epidermis is found in the leaves of Nerium and Ficus
Reason: Inorganic crystals are seen in the leaf cells of Nerium and Ficus
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

28) Assertion: It is considered as “cell brains”
Reason: Nucleus controls and coordinates cellular activities
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

29) Assertion: Plant cell becomes turgid when kept in hypotonic solution
Reason: Fluid – mosaic model supports the differentially permeable nature of plasma membrane
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

30) Study the following lists:

Plant	Chromosome no of generative cell	Chromosome no of Endosperm
I) Onion	40	120
II) Pea	7	21
III) Tobacco	8	28
IV) Rice	12	36

Which two plants shows correct combination
1) II and IV 2) III and IV 3) I and III 4) II and III

31) Study the following table

A) Karyotype B) Genome C) Alleles D) Idiogram	I) Diagramatic representation of diploid chromosome complement II) A pair of genes representing a character III) Characteristic diploid chromosome complement of a series IV) Total number of genes in a single set of chromosomes V) Total number of centrometers of single set

1) A-II, B-III, C-I, D-V 2) A-III, B-IV, C-II, D-I
3) A-III, B-I, C-IV, D-IV 4) A-I, B-IV, C-III, D-II

32) Study the following table:

List –I	List –II
A) Plectonemie B) Centromere C) Telomeres D) Paranemie	I) Loose colling of chromatids II) Ends of chromatids III) Tight coiling of chromatids IV) Colourless constriction of chromosome V) Matrix of the chromatid

1) A-II, B-III, C-V, D-IV 2) A-I, B-II, C-IV, D-III
3) A-III, B-IV, C-II, D-I 4) A-IV, B-V, C-II, D-I

33) Study the following lists:

Structure	Description	Function
I) Telomere II) Satellite III) Centromere IV) Chromomere	Ends of the chromosome Secondary consrictioin Coloured swollen part Beeded structures	Place of attachment of spindle fibres Nuclear Organiser Polarity Active genetic centres

Which two structures show correct combination?
1) I and II 2) IV only 3) III and I 4) II and III

34) Study the following table

Chromosome in anaphase	No of arms	Shape
I) Telocentric	2	I
II) Acrocentric	2	J
III) Metacentric	1	V
IV) Submetacentric	2	L

Which two chromosomes show correct combination?
1) II and IV 2) I and IV 3) III and I 4) II and III

35) Study the following series

Plant	Chromosomes (n)	Chromosomes (2n)
I) Oryza silva	13	26
II) Allium cepa	10	20
III) Pisum sativum	7	14
IV) Saccharum officinarum	40	80

Which two are correct
1) I and II 2) II and III 3) III and IV 4) I and IV

36) Study the following lists:

List –I	List –II
A) Autosomes B) Karyosomes C) Ergosomes D) Allosomes	I) Ribosomes II) X and Y chromosomes III) False nucleoli IV) Somatic chromosomes V) Golgi complex

1) A-IV, B-III, C-V, D-II 2) A-IV, B-V, C-I, D-II
3) A-V, B-III, C-II, D-I 4) A-IV, B-III, C-I, D-II

37) Identify the correct ascending order of the plants with reference to the number of chromosomes
I) Gossypium II) Allium III) Nicotiana IV) Pisum

1) II, IV, I, III 2) IV, II, III, I 3) I, III, II, IV 4) III, I, IV, II

38) Assertion: Prophase chromosome has two chromatids
Reason: Prophase chromosome has two molecules of DNA which are exact replicas of each other
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

39) Assertion: SAT chromosomes have terminal trebent beyond secondary constriction
Reason: SAT chromosomes are found in all eukayotic nuclei
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

40) Assertion: Eukaryotic chromosomes are chemically nucleoproteins
Reason: Eukaryotic nuclear D.N.A is associated with histone proteins
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

41) Assertion: Monocentric chromosomes have one centromere only
Reason: SAT chromosomes have secondary constriction
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

42) Assertion: Anaphasic telocentric chromosomes are single armed
Reason: Telocentric chromosomes have no centromere
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

43) Study the following lists:

List –I	List –II
A) Length of the coil of DNA	I) $20A^0$
B) Diameter of DNA	II) 10
C) Angle between two N_2 base pairs	III) $34A^0$
D) Number of base pairs in one coil of DNA	IV) $3.4A^0$
	V) 36^0

1) A-III, B-V, C-IV, D-II 2) A-IV, B-III, C-II, D-V
3) A-V, B-III, C-IV, D-I 4) A-III, B-I, C-V, D-II

44) Study the following lists:

List –I	List –II
A) Glycosidic bond	I) Between Gaunine and thymine
B) Phosphodiester bond	II) Between sugar and phosphate
C) Two H bonds	III) Between sugar and N2 base
D) Three H bonds	IV) Between Adenine and Thymine
	V) Between Guanine and eytosine

1) A-III, B-II, C-IV, D-V 2) A-IV, B-V, C-III, D-II

3) A-II, B-III, C-V, D-IV 4) A-II, B-I, C-III, D-IV

45) Study the following lists:

List –I	List –II
A) B DNA B) Reo RNA C) ϕ x 174 phage DNA D) TMV RNA	I) Non genetic single stranded RNA II) Double stranded DNA III) Genetic single stranded DNA IV) Double stranded RNA V) Single stranded DNA

1) A-II, B-IV, C-V, D-I 2) A-II, B-IV, C-V, D-III
3) A-V, B-III, C-II, D-I 4) A-II, B-I, C-III, D-V

46) Study the following lists:

List –I	List –II
A) Guanine B) Cytocine C) Adenine D) Uracil	I) 6-amino purine II) 2-6 dioxy pyrimidine III) 2-amino, 6-oxy purine IV) 2 oxy –6 amino pyrimidine V) 2-6 dioxy 5 methyl pyrimidine

1) A-III, B-IV, C-I, D-II 2) A-V, B-I, C-III, D-IV
3) A-IV, B-II, C-III, D-I 4) A-I, B-III, C-IV, D-V

47) Study the following lists:

List –I	List –II
A) DNA B) mRNA C) tRNA D) rRNA	I) Carries message from DNA II) Identifies amino acids III) Regulates various biochemical reactions IV) Synthesis of Ribosomes V) Function not known

1) A-II, B-I, C-III, D-IV 2) A-IV, B-III, C-V, D-II
3) A-I, B-II, C-III, D-V 4) A-III, B-I, C-II, D-IV

48) Study the following lists:

List –I	List –II
A) Bacteriophage B) X-ray diffraction C) Clover leaf model D) Double stranded RNA	I) Holley II) Reo virus III) Double stranded DNA IV) Franklin and Wilkins V) Chargaff

1) A-V, B-IV, C-III, D-I 2) A-III, B-IV, C-I, D-II
3) A-III, B-IV, C-II, D-I 4) A-III, B-II, C-IV, D-I

49) Match the following:

List –I	List –II
A) Autocatalysis B) Z-DNA C) B-DNA D) Heterocatalysis	I) Transcription II) Watson & Crick III) Rodley group IV) S-subphase of cell division V) Protein synthesis

1) A-III, B-II, C-IV, D-I 2) A-IV, B-III, C-II, D-V
3) A-IV, B-III, C-I, D-V 4) A-IV, B-III, C-V, D-I

50) Study the following lists:

List –I	List –II

A) Pauling B) R.Holley C) Joseph Frederic Meischer D) Sashi Sekharan	I) Nucleic acids II) tRNA structure III) B-DNA IV) Z-DNA V) Hydrogen bonds

1) A-V, B-II, C-III, C-I 2) A-V, B-II, C-I, D-IV
3) A-III, B-V, C-II, D-I 4) A-V, B-II, C-IV, D-I

51) Match the following:

List –I	List –II
A) Monocyclic B) Heterocyclic C) Chemical basis of heredity D) Physical basis of Heredity	I) DNA II) Chromosomes III) Purines IV) Pyramidines V) RNA

1) A-IV, B-II, C-III, D-I 2) A-IV, B-III, C-II, D-I
3) A-IV, B-III, C-I, D-II 4) A-III, B-II, C-I, D-IV

52) Match the following:

List –I	List –II
A) Sugar+N_2base+Phosphate B) Sugar+N_2base C) $C_5H_{10}O_5$ D) $C_5H_{10}O_4$	I) Ribose sugar II) Polymer III) Nucleoside IV) Nucleotide V) Deoxy ribose sugar

1) A-IV, B-I, C-V, D-III 2) A-IV, B-I, C-III, D-V
3) A-IV, B-III, C-I, D-V 4) A-I, B-IV, C-III, D-V

53) Study the following table:

Type of nucleic acid	Molecular weight	Percentage in a cell
I) DNA	10,000	25%
II) mRNA	5,00,000	5 –10 %
III) rRNA	$10x10^4$	22 –30%
IV) tRNA	$2.5x10^4$	15%

Which of the following is a correct combination
1) I and II 2) III and IV 3) II and IV 4) I and IV

54) Study the following table:

Nitrogen base	Group	Number of C –N rings
I) Adenine	Pyrimidine	One ring
II) Guanine	Purine	Two rings
III) Cytocine	Purine	Two rings
IV) Thymine	Pyrimidine	One ring

Which of the above two combinations are correct
1) II and IV 2) I and II 3) III and IV 4) IV and I

55) Study the following table:

Type of nucleic acid	Molecular weight	Nucleotides
I) mRNA	10,00,000	Thousands
II) DNA	Above 30,000	Numerous
III) RNA	5,00,000	few hundreds
IV) tRNA	25,000	80 –90

Which nucleic acid shows correct combination
1) I and IV 2) II and IV 3) II and III 4) I and III

56) Study the following table:

Name of the N_2 base	Type of N_2 base	Chemical nature
I) Guanine	Purine	Dicyclic N_2 base
II) Adenine	Pyrimidine	Monocyclic N_2 base
III) Thymine	Purine	Methylated Dicyclic
IV) Uracil	Pyrimidine	Monocyclic

Which two N_2 bases show correct combination
1) I and III 2) I and II 3) II and III 4) I and IV

57) Which of the following types of nucleic acids is involved in protein synthesis?
I) DNA II) RNA III) tb. RNA
1) I and II are correct 2) II and III are correct
3) II alone is correct 4) I and III are correct

58) Messenger RNA was discovered by
I) Holley & Khorana II) Monod & Jacob III) Hershy & Chase
1) II alone is correct 2) II and III are correct
3) I and II are correct 4) I and III are correct

59) Initiation codons are
I) AUG II) GUG III) UAA
1) I and II are correct 2) II and III are correct
3) II alone is correct 4) I and III are correct

60) The chemical basis of heredity is
I) Chromosomes II) RNA III) DNA
1) I and II are correct 2) III alone is correct
3) II and III are correct 4) I and III are correct

61) Identify the correct descending order of the RNAs based on their molecular weight
I) m-RNA II) t-RNA III) r-RNA
1) III, I, II 2) I, II, III 3) II, I, III 4) II, III, I

62) Choose the correct ascending order of the RNAs based on their percentage composition in the cell
I) m –RNA II) r –RNA III) t –RNA
1) II, III, I 2) III, I, II 3) I, III, II 4) II, I, III

63) Z-DNA was discovered by
I) Rodley II) Watson & crick III) Sashisekharan
1) I and III are correct 2) II alone is correct
3) II and III are correct 4) I and II are correct

64) Dicyclic nitrogen bases are
I) Adenine II) Cytosinc III) Guanine
1) I and II are correct 2) II and III are correct
3) I and III are correct 4) III alone are correct

65) Which of the following enzymes are involved in DNA replication
I) Exo nucelases II) DNA polymerase III) RNA polymerase
1) I and II are correct 2) II and III are correct
3) I and III are correct 4) II alone is correct

66) With reference to t-RNA
I) It is also known as soluble RNA
II) Holley proposed clover leaf model of t-RNA molecule
III) It does not participate directly in protein synthesis
1) I and III are correct 2) II and III are correct
3) III alone is correct 4) I and II are correct

67) Single stranded DNA is found in
I) Reo virus II) ϕ x174 virus III) TMV
1) I and II are correct 2) II alone is correct
3) I and III are correct 4) II and III are correct

68) Regarding RNA
I) Thiamine is absent II) Usually single stranded III) Usually genetic material
1) I and III are correct 2) III alone is correct
3) II and III are correct 4) I, II and III are correct

69) Nonsense codons are
I) UAA II) UAG III) UGA IV) AUG
1) I and IV are correct 2) II and III are correct
3) I and II are correct 4) I, II and III are correct

70) Which of the following are not initiating codons?
I) AUG, GUG II) UAA, AUG III) UGC, AUC
1) II alone is correct 2) III alone is correct
3) I, II are correct 4) II, III are correct

71) Assertion: Methylated N_2 base is found in DNA only
Reason: DNA has deoxyribose sugar
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

72) Assertion: Purines are larger than pyrimidines
Reason: Purines have two C –N rings while pyrimidines have one C –N ring
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

73) Assertion: Dephosphorylated nucleotides are nucleosides
Reason: Nucleoside consists of sugar and N_2 base
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

74) Assertion: Chargaff's chemical analysis of DNA shows 1:1 ratio of purines and pyrimidines
Reason: A pairs with T and G with C in single stranded DNA
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

75) Assertion: H-bonds connect the nucleotides of a polynucleotide strand
Reason: Two ends of a polynucleotide strand are polarised
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

76) Assertion: Cellular DNA can be traced with ultraviolet light
Reason: DNA shows absorption maxima at 260nm of wavelength

1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

77) Assertion: DNA is the genetic material in all living organisms except most of the plant viruses
Reason: DNA regulates the heredity in living organisms
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

78) Assertion: DNA replicaes during S.sub phase of interphase
Reason: DNA polymerase is active during S.sub phase of interphase
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

79) Assertion: Base sequence of mRNA is complimentary to that of DNA template
Reason: mRNA is copied from the template strand of DNA
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

80) Assertion: Double stranded RNA is the genetic material in Reo Virus
Reason: RNA is usually the genetic material in plant viruses
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

81) Assertion: RNA rarely shows 1:1 ratio of purines and pyrimidines
Reason: RNA is usually double stranded
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

82) Assertion: mRNA has short life span (or) highly unstable
Reason: mRNA is translated into protein in cytoplasm
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

83) Assertion: tRNA is largely constituted RNA in the cell
Reason: tRNA has lowest molecular wt of all cytoplasmic RNA
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

84) Assertion: DNA is self replicative
Reason: RNA is not self replicative

1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

85) Find out the correct sequence of events during meiosis
I) Disjunction II) Crossing over III) Synapsis IV) Terminalisation
1) III, II, I, IV 2) IV, II, IV, I 3) II, III, I, IV 4) III, IV, I, II

86) Find out the correct match

List –I	List –II
A) Rudolf Virchow B) Walter Fleming C) Stransburger D) Farmer and Moore	I) Disocvery of Mitosis and Meiosis in plants II) Term meiosis coined III) Term mitosis coined IV) Meiosis discovery V) Cell lineage theory

1) A-V, B-III, C-I, D-IV 2) A-I, B-II, C-III, D-IV
3) A-V, B-IV, C-III, D-I 4) A-V, B-III, C-I, D-II

87) Find out the correct match

List –I	List –II
A) Prophase I B) Anaphase C) Interphase D) Farmer and Moore	I) Shortest phase II) Genetically most inactive phase III) Longest phase IV) More active phase

1) A-III, B-II, C-I, D-IV 2) A-IV, B-III, C-II, D-I
3) A-III, B-I, C-IV, D-II 4) A-II, B-IV, C-III, D-I

88) Find out the correct match

List –I	List –II
A) Metaphase B) Anaphase C) Diakinesis D) Crossing over	I) Shape of chromosome II) Exchange of chromatin III) Counting of chromosomes IV) Terminalisation of Telomeses V) Structure of the chromosomes

1) A-IV, B-I, C-II, D-III 2) A-V, B-I, C-III, D-II
3) A-II, B-IV, C-V, D-I 4) A-V, B-I, C-III, D-IV

89) Study the following lists:

List –I	List –II
A) Crossing over B) Synapsis C) Bouquet stage D) Terminalisation	I) Diplotene II) Zygotene III) Leptotene IV) Pachytene V) Diakinesis

1) A-IV, B-II, C-III, D-V 2) A-V, B-III, C-II, D-I
3) A-IV, B-II, C-V, D-III 4) A-III, B-II, C-IV, D-V

90) Study the following table regarding Pisum sativum

Phase	Chromosome number	Chromatid number
I) Anaphase II	14	28
II) Metaphase I	14	28
III) Telophase II nucleus	7	7
IV) Telophase	7	7

Two phages show correct combination

1) I & II 2) II & III 3) III & IV 4) I & IV

91) Study the following table

Event	Phase	Result
I) Synapsis II) Crossing over III) Disjunction IV) Terminalisation	Zygotene Pachytene Diplotene Diakinesis	Bivalent formation Recombinations of genes Segregation of bivalent Movement of genomes to opposite poles

Find out the correct are

1) I & III 2) I & IV 3) I & II 4) III & IV

92) Find out the incorrect match

1) Leptotene	Boquet stage
2) Anaphse II	Disjunction
3) Pachytene	Crossing over
4) Metaphas I	Orientation of bivalents

Keys

1)1	2)1	3)1	4)3	5)4	6)1	7)2	8)4
9)3	10)1	11)1	12)4	13)1	14)2	15)1	16)4
17)3	18)1	19)2	20)3	21)1	22)1	23)1	24)1
25)2	26)3	27)2	28)1	29)1	30)1	31)2	32)3
33)2	34)1	35)3	36)4	37)2	38)1	39)2	40)1
41)2	42)3	43)4	44)1	45)2	46)1	47)4	48)2
49)2	50)2	51)3	52)3	53)3	54)1	55)2	56)4
57)1	58)1	59)1	60)2	61)1	62)3	63)1	64)3
65)4	66)4	67)2	68)1	69)4	70)4	71)2	72)1
73)1	74)3	75)4	76)4	77)1	78)1	79)1	80)2
81)3	82)2	83)4	84)2	85)2	86)4	87)3	88)2
89)1	90)2	91)3	92)2				

UNIT -VI
INTERNAL ORGANISATIONS OF PLANTS

TISSUES

- Tissue is defined as 'group of cells which are similar in origin & function'
- In heigher plants the cells are organised into tissues, tissue system & organ
- The study of tissues is known as Histology
- Plant tissues are classified into two major types ----
  I. Merestematic tissue (Meristems)
  II.Permanent tissue

I. Merestematic Tissue: (Meristems)

- It is defined as 'a group of immature cells which devide activity & shows active metabolism'.
- The term meristem was coined by Nageli (1858)

Characters of Meristems:

- Cells are small
- Cells may be isodiametric, cuboidal or polygonal in shape
- Cells are arranged compactly without intercellular spaces
- Cells walls are thin & cellulosic
- Cytoplasm is dense with conspicuous nucleus
- Vacuoles are minute & numerous
- Proplastids are present, ergastic substances are absent
- Cells divide activity & continuously

1. Classification of Meristems: On the basis of origin, meristems are classified into two types ----

a) Primary meristems
b) Secondary meristems

Primary Meristems: 'Originates from embryonic meristems'.

- They remain merestematic throughout the life of plant body
- They are present at the tips of growing regions & vascular bundles

Secondary Meristems: 'Originates from permanent tissues'.

- They are not present in embryonic stage but develops at later stage
- They are found at lateral positions of axis & parallel to plant surface
- Interfascicular cambium, cork cambium & cambium of roots
- Secondary meristem helps in secondary growth & results in radial growth in stem & roots

2. Classification of Meristems based on Position: On the basis of position meristems are classified into 3 types ----

a) Apical meristem
b) Intercalary meristem
c) Lateral meristem

Apical Meristem: They are present at the apex of stem, root & branches.

- It helps in linear growth of plant

Intercalary Meristem: It is found between permanent tissues & are short lived

- During growth of axis, apical meristems are separated from the apex
- They are present at the base of internodes & leaf sheaths of grasses

- They help in linear growth of stem & leaf

Lateral Meristem: It occurs at the lateral sides of plant body

- These cells divides periclinally & increase the thickness of stem & roots
- It helps in secondary growth & produces secondary Xylem, secondary pholem & periderm

  Ex: Vascualr combium & cork cambium

3. Classification of Meristems based on Planes of division: On the basis of planes of division meristems are of 3 types ----

a) Mass meirstems
b) Rib meristems
c) Plate meristems

Mass Meristems: It divides in all planes & produce mass of cells. It is found in endosperm ,young embryo & sporangium

Rib Meristems: These cells divide periclinally (parallel to cell surface). It is also called as file meristem. These cells divide only in one plane & produce cells in longitudinal rows. They are involved in the development of cortex & medulla
Ex: Periblem

Plate Meristem: It divides anticlinally (perpendicular to cell surface in two plane). The derivatives of plate meristem are present in a single layer

- They are involved in the development of epidermis flat leaf lamina

  Ex : Protoderm

MERISTEMATIC TISSUE

Based on Origin — Based on Position — Based on Plane of Division

Primary Meristem — Secondary Meristem — Apical Meristem — Intercalary Meristem — Lateral Meristem

Mass Meristem — Rib Meristem — Plate Meristem

II. Permanent Tissue: "Group of mature cells which have lost the power of division either temporarily or permanently & perform a specific function" is known as permanent tissue.

- Cells are bigger in size, uninucleate
- Cytoplasm is peripheral & vacuole is central
- Cell wall may be thin or thick
- Cells contains different kinds of ergastic substances
- Cells may become meristem if necessary (dedifferentiation).

Permanent tissue is classified into ----
a) Simple Tissue
b) Complex Tissue
b) Special Tissue

SIMPLE TISSUE

It consists of "a group of cells which are similar in structure & functions"

- Simple Tissues are of three types
  i) Parenchyma
  ii) Collenchyma
  iii) Sclerenchyma

i) Parenchyma:

- It is the most common tissue present in softer parts of plant body like epidermis Cortex, pericycle, medulla, mesophyll, pulp of fleshy fruits, embryo & endosperm.
- It occupies major parts of plant body
- It is the most primitive tissue from which other tissues have been evolved & hence This tissue is alos known as fundamental tissue
- It is the tissue in which other tissues like vascular tissues are embedded & hence this tissue is also known as ground tissue
- In lower plants only parenchyma is present which performs all functions

Structure: Parenchyma is a living tissue which consists of round, polygonal, rectangular or irregular cells.

- Cells are arranged loosely with intercellular spaces
- Primary cell walls are composed of cellulose, hemicellulose & pectin
- Parenchyma of secondary xylem are thick due to lignified secondary walls
- Parenchyma of endosperm of Phoenix are thick due to deposition of hemicellulose
- Cells shows thin layer of peripheral cytoplasm with large central vacuole (primoridal utricle)

Types of Parenchyma: Different types of parenchyma are ----
i) Chlorenchyma
ii) Aerenchyma
iii) Storage parenchyma
iv) Secondary parenchyma

i) Chlorenchyma: Parenchyma which contains a large number of chloroplast is called as chlorenchyma. It is concerned with photosynthesis. It is present in leaves, unripe fruits, young stems & branches.

ii) Aerenchyma: Parenchyma which shows large intercellular spaces is known as aerenchyma. It is filled with air. It helps in exchange of gases & also give buoyancy to make the plant float on water surface. Ex: Hydrophytes

iii) Storage Parenchyma: Parenchyma which stores water & food materials is known as storage parenchyma. In fruits, seeds tubers, leaf bases of onin etc; it stores food material. In succulent Xerophytes such as Agave, Aloe, Opuntia etc; it stores large amount of water due to the presence of hydrophilic mucilaenous substances. In some plants, parenchyma stores resins, tannins, gums & inorganic substances.

iv) Secretory Parenchyma: In some parenchyma cells, non-lignified secondary walls shows several invaginations which are lined by plasma membrane. Such cells are known as transfer cells. Ex: Glandular cells. They are concerned with secretion & also helps in transport of food materials.

Functions of Parenchyma:

- Parenchymatous cells undergo dedifferentiation & may become meristematic
- It helps in healing of wounds & regeneration of lost parts.
- Chlorenchyma helps in photosynthesis
- Storage parenchyma helps in storage of water & food material
- Aerenchyma helps in exchange of gases & give buoyancy to hydrophytes.
- Parenchyma of epidermis gives protection & prevents evaporation of water.
- Xylem & Phloem parenchyma helps in conduction of water, organic & inorganic materials
- Parenchyma stores water, materials like tannins gums, resins, oils, calcium oxalate crystals etc.
- Turgid parenchyma provides mechanical strength in herbaceous plants.

Collenchyma: Cells are called as collocytes.

- It is living mechanical tissue
- It is present in Young stems, petioles, leaf margins, veins, pedicel & peduncle.
- It is present as continuous band beneath the epidermis. Ex: Helianthus annus
  It may be in the form of patches below epidermis. Ex: Cucurbita
- It is absent in underground parts. It is rarely found in roots exposed to sunlight.
  It is also absent in leaves & stems of monocots.

Structure: It is a simple tissue consisting of one type of cells.

- The cells are more or less elongated, long or short. The shape is variable.
- Longer cells hare tapering ends.
- Intercellular spaces may or may not be present.
- Cell wall is made up of cellulose or pectin & contains high percentage of water (60%).
- Primary pit fields are present. Cell walls are unevenly thickened.
- Generally cell corners are excessively thickened as a result intercellular spaces are reduced or absent
- Each cell of collenchyma shows thin layer of cytoplasm, peripheral nucleus & large central vacuole. Chloroplast is also present. Some of the cells may also contain tannins.

Types of Collenchyma: On the basis of thickening of cell wall, Majumdar (1941) classified collenchyma into three types----

i) Angular collenchyma
ii) Lacunar collenchyma
iii) Lamellar collenchyma

Angular Collenchyma: The cells are irregularly arranged. Thickening in confined to the corners of the cells as a result intercellular spaces are absent. Lumen appears circular due to continued deposition of wall materials.
Ex: Stems of Solanum tuberosum, Datura, Cucurbita, Polygonum etc.

Lacunar Collenchyma: The cells irregularly arranged. The cell walls shows excessive thickening around the intercellular spaces as a result spaces reduces.
Ex: Stems of Althea, Malva, Leucas, Lactuca & aerial roots of Monstra.
(Lacunar collenchyma is also known as tubular collenchyma)

Lamellar Collenchyma:In this type, cells are arranged in parallel rows (horizontal rows). Thickening is confined to tangential walls; radial walls are thin. Intercellular spaces are absent. Cells appears as bands or plates hence it is also known as Plate collenchyma

Ex: Stems of Sambucus, Clerodendron, Eupatorium, Rhamnus etc.

Functions:

- It gives mechanical strength & elasticity to growing organs hence growing organs bends freely in all directions.
- It also helps in Photosynthesis
- It may regain power of division & form secondary meristems.

Selerenchyma: It is dead mechanical tissue present in mature organs of the plant body. It is distributed in cortex, pericycle, xylem & phloem.
It provides strength & hardness to the plant parts.

Structure: The cells of Sclerenchyma are dead. They lack protoplasm.

- Cell walls are made up of cellulose. Secondary walls are lignified.
- Simple pits may be present.
- Lumen is greatly reduced due to the presence of highly thickened walls.
- On the basis of size & shape, two types of cells are present in sclerenchyma.
  i) Fibres ii) Sclereids

Fibres: Elongated cells with tapering ends are known as fibres.

- They are longest cells in higher plants.
  1 – 3mm in Angiosperms, 2 – 8mm in Gymnosperms
- They overlap, interlock & occurs as longitudinal rows, hence give mechanical strength.
- In transverse section they appear angular
- Intercellular spaces are absent
- Cell walls are hard, uniformly thickened & lignified
- Pits are small or slit like
- Lumen is greatly reduced
- In Linum usitatissimum (flax), fibres are made up of cellulose & are known as flax fibres. They have high commercial value.
  Fibres are found in cortex, pericycle, vascular tissue & around vascular bundles.

Types of Fibres: Fibres are classified into 2 types ---
i) Intraxylary fibres ii) Extraxylary fibres

Intraxylary Fibres:

- Fibers occuring in Xylem are known as intraxylary fibers. Also known as wood fibers.
- They are further classified into ----
  a) Libriform fibres b) Fibre tracheids
- Libriform fibres are true fibres & have simple pits
- Fibers trancheids are reduced tracheids with boardered pits.

Extraxylary Fibres:

- Fibres present outside xylem are known as extraxylary fibres. They are elongated & have simple pits
- They are further classified into ---
  i) Cortical Fibres ii) Pholem Fibres iii) Pericyclic Fibres
- Fibres found in cortex are known as cortical fibres
- Fibres found in pericycle are known as pericyclic fibres
- Fibres found in pholem are known as pholem fibres
  They are also known as bast fibres.

Functions:

- Fibres give mechanical strength to plant.

- They protect other tissues from harmful effects of bending, weight, pressure etc.
- They have great economical value & used in manufacture of thread, cloth, ropes, mats, carpets etc.
  Ex: Hemp, Flax, Jute, Aloe, etc

Sclereids: Short or slightly elongated sclerenchymatous cells are known as sclereids.

- The term sclereid was given by Tschirch (1885)
- They are Isodiametric or irregular in shape.
- Sclereids have very thick & heavily lignified. Secondary wall & highly reduced lumen.
- The walls shows simple pits.
- Sclereids may occur singly or in groups.
- Sclereids which occurs singly are called idioblast sclereids.
- Sclereids are generally present in soft tissues cortex, pholem, medulla, fleshy fruits, leaves & seed coats etc.
- They give hard texture to seed coats, pericarp etc.
- They are classified into different types such as ----

a) Brachysclereids:

- They are short & isodiametric sclereids which resembles parenchyma in their shape.
- They are present in soft parts like cortex, phloem, pulp of fruits etc.
- They are also known as stone cells due to their hard cell walls.
  Ex: Pyrus, Cydonia, Annona, Psidium, Coconut, Nicotiana etc.

b) Macrosclereids:

- They are slightly elongated elongated, columnar (rod – shaped) cells.
- They form palisale – like epidermal layer in the seed coats of legumes.
- They are also known as malpighian cells. Ex: Pisum, Dolichos etc.

c) Osteosclereids:

- They are bone – shaped sclereids
- They are also rod like with enlarged or lobed ends
- They are found in leaves & seed coats. Ex: Haekea, Mouriria

d) Astrosclereids:

- Star shaped or stellate sclereids
- They are variously branched & look like star.
- They are present in petioles & leaf bades.
  Ex: Tea (Camella species), Nymphaea

e) Trichosclereids:

- They are elongated & hair like sclereids
- They are branched. Branches extends into intercellular spaces
- They are found in stems & leaves of hydrophytes
  They are also found in leaves of Olea & arial roots of Monstera.

Functions:

- Sclereids give mechanical strength to plant.
- They give rigidity & hardness to the plant parts like leaves, seed coats etc.

COMPLEX TISSUES

- It is a permanent tissue having more than one type of cells. Which acts as a functional unit & carry out common function.
- It is also known as heterogenous tissue as different cells constitute complex tissue

- In vascular plants Xylem & Phloem are complex tissue which constitutes vascular bundles & are concerned with conduction.
- Xylem – helps in conduction of water & minerals from roots to other parts of plants
- Phloem – helps in conduction of food materials from leaves to other parts of plant body.

  $\left.\begin{array}{l}\text{Xylem (Hydrome)}\\ \text{Phloem (Leptome)}\end{array}\right\}$ Vascular tissue

Xylem: It is a complex tissue & helps in conduction of water & minerals

- It is also known as hydrome
- The term xylem was coined by Nagali (1858).
  (Xylos means wood)
- Xylem is heterogenous tissue consisting of different types of cells ----
  i) Tracheids ii) Trachea iii) Xylem Fibers iv) Xylem parenchyma
- Of these cells only xylem parenchyma is living cells

i) Tracheids:

- The term 'tracheid' was introduced by Sanio (1863)
- Tracheids are elongated cells with tapering ends.
- In cross section they appear round, rectangular, angular or polygonal in outline.
- Tracheids consists of large lumen & thick lignified walls.
- Protoplasm is absent & hence they are dead cells
- Secondary thickening may be annular, spiral, Scalariform, reticulate or pitted.
- They are connected to one another laterally & at their ends.
- Water & minerals are conducted in upward direction through lateral walls or pits.
- They are main components of Xylem in Pteridophytes & Gymnosperms. Also found in secondary Xylem of dicots.
- The main function of tracheid is to conduct water & minerals. They also provide mechanical strength due to the presence of hard-lignified walls.

ii) Vessels or Trachea:

- They are long, tube like structures
- They are formed form a row of cylindrical cells which are arranged one above the other.
- End walls of cylindrical cells dissolve as a result vessels are formed.
- They are also known as trachea as they resembles trachea of insects
- The cells which form vessels are known as vessel elements
- Each vessel consists of large lumen & thick lignified walls. Protoplasm is absent.
- Secondary thickening may be annular, spiral reticulate, scalariform or pitted.
  Annular thickening $\rightarrow$ in the form of rings
  Scalariform thickening $\rightarrow$ in the form of helix
  Scalariform thickening $\rightarrow$ in the form of ladder
  Reticulate thickening $\rightarrow$ net like.
  Pitted thickening $\rightarrow$ leaving pit like thin areas
- Annular & spiral thickenings are found in protoxylem. Where as scalariform, reticulate & pitted thickening is found in metaxylem.
- The unthickened areas found on end walls are known as pits.
- Pits may be simple or bordered.

- The pit in which pit cavity is uniform is known as simple pit. They are found in vessels, Xylem fibers & Xylem parenchyma.
- The pit in which the secondary wall over aches the pit cavity is known as borded pit.
  Each bordered pit consists of pit cavity which opens outside by pit aperture. Pit cavity shows a membrane. The central part of pit membrane is thickened & is called as torus. The thin membrane shows movements due to which torus may touch pit aperture. Pit helps in conduction of water & minerals.
- Vessels are connected to one another through pores which are present on end walls.
- The part of cell wall which have pores are known as perforation plate.
- Vessels are present in most of Angiosperms (absent in Yucca, Dracaena, Drimys), Some Pteredophytes (Selaginella) & Gymnosperms (Gnetum)
- The main function of vessels is conduction of water & minerals. They also provide mechanical support

iii) <u>Xylen Fibres</u>: (Wood Fibres)

- The fibres found in Xylem are known as Xylem fibres
- Xylem fibres are dead cells with extremely thick & lignified walls. The lumen is narrow.
- Xylem fibres are of two types ----
  a) Libriform fibres b) Fibre tracheids
- Libriform fibers are true sclerenchymatous fibers. They are thin, long; thick walled with narrow lumen. Simple pits are present
- Fibre tracheids are intermediate between tracheids & fibres. The walls are thin & lumen is broad. Bordered pits are present
- Fibres give mechanical strength to plant body.

iv) <u>Xylem Parenchama</u>: (Wood Parenchyma)

- Parenchyma found in Xylem is known as Xylem parenchyma
- These are the only living cells of Xylem
- Cells have thin cellulosic cell walls
- In Primary Xylem these cells are arranged in vertical rows
- In Secondary Xylem, it is of two types ----
  axial parenchyma, ray parenchyma
- The cells of axial parenchyma are vertically elongated & arranged in vertical rows.
- The cells of ray parenchyma are radially elongated & arranged in radial rows
- Xylem parenchyma stores food materials & also helps in Lateral conduction of water & minerals

<u>Phloem</u>: (Leptome)

- Phloem is complex, heterogenous tissue which helps in conduction of food materials.
- It is also called as bast or leptome.
- The term leptome was coined by Haberlandt
- The term Phloem was coined by Nagali (1858)
- It consists of four types of cells ----
  i) Sieve elements ii) Companion cells iii) Phloem fibres iv) Phloem parenchyma

i) <u>Sieve Elements</u>:

- These are the conducting elements of Phloem
- Sieve elements are of two types ----

a) Sieve cells b) Sieve tubes

a) Sieve cells:

- These are the primitive type of conducting elements found in Pteridophytes & Gymnosperms
- Sieve cells are narrow, elongated cells with oblique or tapering ends
- Mature sieve cells are enucleated, therefore it is living cell without nucleus
- The area of cell wall with several minute pores is known as sieve area
- Sieve areas occurs all over the sieve cell
- Sieve cells overlaps with each other & helps in conduction of food materials

b) Sieve tubes: These are advanced type of conducting structures.

- These are slender, elongated, tube- like cells
- They were first discovered by Hartig (1837)
- They are formed by fusion of a row as syncytes of elongated cells hence also described as syncytes.
- The cells which form sieve tubes are known as sieve tube elements
- Sieve tubes is broader & is surrounded by thin cellulosic cell wall
- Thin layer of cytoplasm is present to cell wall. Centre is occupied by large vacuole
- Vacuole is filled with viscous & albuminous substances (proteins) known as slime.
- Nucleus is present in young sieve tube but absent in mature cells i.e. living cells
- The ends walls of sieve tubes are transverse or oblique & are called as sieve plates. They are perforated. The perforations are known as sieve pores.
- The parts of sieve plates consisting of sieve pores are known as sieve areas.
- Sieve plates may consists of one or more sieve areas
- Sieve plate consisting of many sieve area is called as simple sieve plate.
  Ex: Cucurbita
  Sieve plate consisting of one sieve plates is known as compound consisting of many sieve plates is known as compound sieve plate. Ex: Vitis
- Sieve tubes establish continuity with one another through sieve pores.
- The walls of sieve tubes are usually non – lignified
  In Dicots, Sieve tubes contains viscous substance called slime which accumulates on sieve area & form "slime plug" when phloem is processed for microscopic observation in live or killed state.
- Presence of slime plug indicates that the cell has been injured
- Cytoplasmic strands in the sieve area are associated with carbohydrate called callose. In old sieve tube elements heavy accumulation of callose is noticed on sieve areas forming 'callose plug' that block sieve pores.
- Sieve tubes are found only in Angiosperms & absent in Pteridophytes & Gymnosperms
- The help in conduction of food materials

Companion Cells:

- These are special parenchymatous cells associated with sieve tubes
- Companion cells & sieve tube arises from same mother cell by longitudinal division. Hence they are sister cells
- Companion cell may be as long as sieve tube or may divide transversely to form companion cells. In cross section they appear triangular, rectangular or polygonal.
- It consists of thin cellulose cell wall, vacuolated cytoplasm & large nucleus
- It shows cytoplasmic connection with sieve tube through pits & plasmodesmata

- Companion cells are present only in Angiosperms and are absent in Pteridophytes & Gymnosperms where albuminous cells are associated with sieve cells
- Companion cells helps in translocation of food materials

Phloem Fibers:

- Fibers present in phloem are called as phloem fibers or bast fibers
- They are long & narrow with pointed ends. They overlap each other.
- Fibers of primary phloem have cellulose cell wall where as fibers of secondary phloem have lignified walls. The walls shows simple pits.
  Bordered pits are rarely present
- Fibers may be living or dead. Living fibers stores food materials
- Secondary phloem fibers have commercial value
  They are useful in textile & cordage industry
- Dead fibers give mechanical support to plant body
- High quality jute is obtained from Corchorus capsularis (jute plant)

Phloem Parenchyma:

- Parenchyma present in phloem is known as phloem parenchyma
- The cells may be longer, broader, polyhedral.
- The cells are living & are surrounded by cellulosic cell wall
- Secondary phloem consists of both axial parenchyma & ray parenchyma where as primary phloem consists of only axial parenchyma
- Cells of axial parenchyma are vertically elongated
  Where as cells of ray parenchyma are radically elongated
- Ray parenchyma helps in radial conduction of food
- Phloem parenchyma helps in storage of food materials
- Phloem parenchyma is found in dicots & some monocots. It is absent in many monocots

SPECIAL TISSUES

- The cells or tissues concerned with secretion or excretion of materials constitute special tissue or secretory tissue
- The cells have dense cytoplasm rich in proteinaceous substances & are polyploids
- The secretions are produced by cytoplasm which comes out of the cells. Some times the secretions are stored in glands, ducts or specialsed cells.
- The secretions includes enzymes, nector, gums, oils, latex & resins etc.
- Special tissues (secretory tissues) are classified into different types on the basis of kinds of materials secreted & place of secretion
- Different types of special tissues are ----
  digestive glands, nectaries, hydathodes, osmophores, secretory cavities & Laticiferous tissue

Digestive Glands:

- Special glands which secretes digestive enzymes is known as digestive glands.
  Ex: Drosera, Nepenthes, Dionea etc
- These glands secretes protein digesting enzymes i.e. proteolytic enzymes which digest insect proteins
- This type of digestion is known as extra cellular digestion

Nectaries:

- Special glands which secretes nectar or honey are known as nectaries

- They are present in entamophilous plants on floral parts or vegetative parts
- Nectaries present on floral parts are known as floral nectaries.
  Ex: Nectaries present on vegetative parts is known as extra floral nectaries
  Ex: Passiflora – glands are found on petioles
- Nectaries are formed from epidermal or sub- elongated cells. Nacteries consists of a layer of elongated & palisade like cells. The cells have dense cytoplasm & prominent nuclei. The walls are thin.
- The cells secretes nectar directly at their surface
- Nectar attracts insects which helps in cross pollination

Hydathodes: (Water Stomata)

- Water secreting structures present along the margins & apex of the leaves are called as Hydathodes
- They are found in herbaceous Angiosperms growing in humid areas
- Water escapes through hydathodes in the form of liquid. “Escape of water from the plant in the form of liquid is known as guttation”
- Guttation occurs when atmosphere is excessively humid.
  Gutted water drops can be observed along the margins of leaves of herbs, aroids & grasses
- Hydathodes consists of an aperture surrounded by two guard cells which have lost the power of controlling the size of aperture hence aperture always remains open. Beneath the aperture air cavity is present that is followed by loosely arranged parenchymatous cells called epitheme. Beneath the epitheme vein – endings are present consisting of tracheids which represents the end of vascular bundle.
- From the vein endings, water moves inot the cavity through epitheme cells & finally comes out particularly on humid cool morning.
- Guttation can be seen in plants like Colocasia, Lycopersicon, Pothos, Tropaeolum & many grasses.
- The water drops shines in sun rays are referred as dew drops

iv) Secretory Cavities:

- The spaces in which secretory substances such as resins, oils, gums, nectar, enzymes & hormones are stored are known as secretory spaces.
- They may be in the form of ducts or cavities
- On the basis of origin secretory cavities are classified into ----
  a) Schizogenous cavities b) Lyzigenous cavities

Schizogenous Cavities:

- These cavities are formed by the enlargement of intercellular spaces
- These cavities are lined by layer of secretory cells called epithelial cells. Cells have dense cytoplasm & prominent nuclei.
- These cells release their secretions into the cavity.
  Ex: Resin ducts of Pinus, mucilage cavities of Helianthus

Lysigenous Cavities:

- These cavities are formed by the Lysis of glandular cells.
- They are large, irregular & are lined by disintegrated cells.
- In the beginning these cells are vacuolated & contains the secretions
- When these cells disintegrate the secretory substances are released & retained in the cavity.
  Ex: Oil cavities in Citrus, Eucalyptus

Laticiferous Tissue:

- Latex is an important plant secretion. It is emulsion of proteins, sugars, alkalois & other substances. Mostly it is milky white in colour but may also be colourless, yellow to orange coloured.
- Latex is produced by specialized cells known as laticiferous tissue (laticifer). It is found in members of Asteraceae, Apocynaceae, Euphorbiaceae, Asclepiadaceae etc.
- Laticiferous tissue is of two types -----
  a) Latex cells b) Latex vessels

Latex Cells:

- They are individual cells & are small in size
- In the beginning they are uninucleate but become multinucleated due to free nuclear divisions.
- They may be branched or unbranched
- They are also known as simple laticifers or non – articulated laticifers
- The cell walls are thin & cellulosic. Thin layer of cytoplasm is present beneath cell wall. Inner to cytoplasm latex is present
  Ex: Calotropis, Ficus, Nerium, Euphorbia etc

Latex Vessels:

- They are formed by vertical rows of latex cells. The cross walls between the cells disintegrate due to which cells fuse to form long vessels.
- Latex vessels are surrounded by thin cellulose cell wall inner to which thin layer of cytoplasm is present. Cytoplasm contains numerous nuclei. Inner to cytoplasm latex is present.
- Initially latex vessels are unbranched but later on becomes branched as the plant grows.
- Latex vessels become connected laterally to form network hence are called as articulated latex vessels or compound laticifers
  Ex: Members of Asteraceae, Pepara€raceae, Musaceae & Hevea of Euphorbiaceae
- Rubber is extracted from H.brasilien sis
  Morphine is extracted from Pepaver (Opium poppy)
  Indian rubber is obtained from Ficus elastica

Tyloses:

- In many plants Xylem parenchyma develops ballon like structures into tracheary elements. Which are known as tyloses
- They are formed by the enlargement of pit membrane & block the lumen
- Their walls are thin but later become lignified
- Tyloses are formed when Xylem elements become inactive or when they are injured.
- They prevent the conduction of water & minerals & also prevent movement of fungal hyphae

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Dicot Root

- Epidermis – Root hairs → Absorption of water
- Cortex
  - Exodermis → Prevents exist of water from the root
  - General cortex → Stores food materials and helps in Lateral conduction of a water and mineral ions
  - Endodermis → Prevents the leakage of water from the stele and transportes water into xylem Through passage cells
- Stele
  - Pericycle → Formation of lateral and secondary Cambium
  - Vascular bundles → Xylem helps in conduction of water Phloem helps in transport of food materials
  - Conjunctive tissue → Storage of food materials Formation of secondary cambium
  - Medulla → Very small or absent

Orngaisation and functions of tissues in primary dicot root

Monocot Root

- Epidermis — Root hairs → Absorption of water and mineral ions
- Cortex
  - Exodermis → Prevent exit of water from the root
  - General cortex → Stores food material and helps in lateral Conduction of water
  - Endodermis → Prevents leakage of water from the stele and helps in conduction of water and Mineral ions into the xylem
- Stele
  - Pericycle → Produces lateral roots
  - Vascular bundles → Xylem helps in conduction of water And mineral ions Phloem helps in transport of food Materials
  - Conjunctive tissue → Stores food materials
  - Medulla → Stores food materials

Orgnaisation and functions of tissues in monocot root

- Dicot stem
  - Epidermis
    - Stomata → Helps in loss of water and exchange of gases
    - Cuticle → Protects from desiccation
    - Trichomes → Protects the inner part and checks transpiration
  - Cortex
    - Hypodermis — Collenchyma → Provides elasticity to the stem
    - General cortex
      - Chlorenchyma → Synthesis food materials
      - Achlorophyllous → Stores food materials
    - Endodermis — Casparian thickenings → Barrier between Cortex and stele
  - Stele
    - Pericycle — Sclerenchyma → Gives mechanical strength
    - Vascular bundles — Conjoint, collateral, open and endarch → Conducts water, mineral ions and food materials
    - Medulla — Parenchyma → Stores food materials
    - Medullary rays — Parenchyma → Lateral conduction

Organisation and functions of tissues in Dicot stem

- Monocot Stem
  - Epidermis
    - Cuticle → Prevents loss of water
    - Stomata → Help in exchange of gases and escape of Water vapour
  - Hypodermis — Sclerenchyma → Provides mechanical support
  - Ground tissues — Parenchyma → Stores food materials
  - Vascular bundles
    - Xylem → Conducts water and mineral ions
    - Phloem → Transport food materials

Organisation and functions of tissues in Monocot stem

- Dicot Leaf
  - Epidermis
    - Upper epidermis
    - Lower epidermis
      - Cuticle → Prevents evaporation
      - Trichomes→ Protects the plant
      - Stomata → Helps in gaseous exchange
  - Mesophyll
    - Palisade parenchyma → Carries out photosynthesis
    - Spongy parenchyma → Carries out photosynthesis Helps in gaseous

exchange

  - Vascular bundles
    - Xylem→ Conducts water and mineral ions
    - Phloem → Transports food materials

Organisation and Functions of Tissues in Dorsiventral Leaf

Secondary Growth in Dicot Stem

- Apical meristems cause linear growth and give primary structure
- Growth in thickeness (diameter) of stem and root is called secondary growth
- It is commonly found in Gymnosperms and Dicots
- It is absent in Pteridophytes, Monocots and Hydrophyte
- But some monocots exhibit anolomous secondary growth ex: Dracaena, Yucca
- Secondary growth is absent in leaves
- Lateral meristems cause secondary growth
- It is divided into two stages:

I) Intra stelar changes
II) Extra stelar changes

I) **Intrastelar Changes**:

- Production of secondary tissues in stele region
- First step is formation of vascular cambial ring
- Inter fascicular cambium is formed by dedifferentiation of medullary ray cells
- Inter fascicular cambium joins with intra cambium to form vascular cambial ring
- Vascular cambium is partly primary (intra fascicular) and partly secondary (inter fascicular) in origin.
- Vascular cambium consists of two types of initials:
  1) Fusiform initials 2) Ray initials

1) **Fusiform initials**:

- Undergo periclinal divisions
- Outer daughter cells differenciate into secondary phloem
- Inner daughter cells differenciate into secondary xylem
- More amount of secondary xylem is produced than secondary phloem
- Secondary xylem consists of tracheids, vessels, fibres, parenchyma
- Secondary phloem consists of sieve tubes, companion cells, phloem fibres and phloem parenchyma

2) **Ray initials**:

- Undergo pericilinal divisions
- Outer cells differenicate into phloem rays or blast rays
- Inner cells differenicate into wood rays or xylem rays
- Phloem ray and xylem ray together called vascular ray
- Vascular rays are uniseriate or biseriate or multiseriate
- They help in lateral conduction and storage

Growth rings or Annual rings or Seasonal rings

- Growth rings are formed in temperate and cold regions
- Growth rings do not form in tropical regions and sea shores. Annual rings do not appear clearly because the seasonal variations are not sharp. Hence these are called '**growth marks**'
- In spring season more leaves and more flowers are formed and plant requires large amounts of water and salts
- So, vascular cambium produces more number of xylem vessels having wider lumen. This is known as Springwood or Early wood
- In Autum, plants are less active and do not require more water and minerals. Hence, VC produces less number of xylem vessels having narrow lumen. This is known as 'Autumn wood' or 'Late wood'
- Two types of woods are produced in one year
- They appear in the form of circles alternatively in T.S. of a trunk. These are called 'Growth rings or Annual rings'

Dendrochronology or Growth ring analysis:

- By counting the number of annual rings, approximate age can be estimated
- Present age of Sequoiadendron in America is about 3,500 years

Pseudo annual rings:

- Annual rings formed due to hormonal charges or heavy leaf fall or due to diseases

- Annual rings are indicative of phonological changes that have occurred in the past few years

Heart wood and sap wood:
- **Heart wood**: Older wood looses water and stores food substances
- Infitrated with oils, gums, resins, tannins, colouring agents and aromatic substances. Hence it appear dark in colour
- Position – Centrally located
- Also know as '**duramen**'
- Hard and higly durable
- Non functional
- Diameter increases with age
- It cannot conduct water and salts because of the growth of tyloses in the lumen of xylem vessels
- It gives mechanical strength to the tree

Sapwood:
- Also known as '**alburnum**'
- Newly formed secondary xylem
- Light in colour
- Functional – conducts water & salts
- Storage of food materials
- Tyloses are absent
- Sapwood gradually converts into heart wood
- Sapwood remains uniformly thick

II) Extrastelar changes/ Cortical secondary growth:
- Periderm- secondary protective layer formed in cortex seocnary growth
- Phellogen or cork cambium gives rise to the periderm
- Phellogen is formed by dedifferentiation of cortical cells
- Phellogen is completely secondary and lateral meristem
- Vascualr cambium is partly primary and partly secondary and lateral meristem
- Phellogen divides periclinally and cuts off new cells on either side

Cork or phellem:
- Tissue produced on the outside
- Cubical or rectangular shape
- Dead, arranged completely in radial rows without intercellular spaces
- Lumen is filled with air or resinous coloured substances
- Impermeable to gases and water due to suberin
- Cork cells, without suberin are called '**Phelloids**'
- Cork is used in the manufuacture of bottle stoppers

Secondary Cortex or Phelloderm:
- Tissue produced to the inside is called phelloderm
- Living tissue with chlorenchyma
- Assimilatory tissue
- Phellem, phellogen and phelloderm together form '**periderm**'

Lenticels:
- Bulged, lens shaped structures in periderm
- Useful for exchange of gases and also for transpiration
- Loose mass of living non suberised parenchyma are called 'Complimentary cells'

Bark:

- All the tissues outside the vasucalr cambium constitute 'Bark'
- Innermost part of bark is secondary phloem
- Outermost part of bark is cork

INTERNAL ORGANISATION OF PLANTS

Match the following Questions:

Ex – 1

1) Sieve cells and Sieve tube elements differ in
   1) Degree of differentiation of Sieve areas
   2) Retention of nucleus even upon maturity
   3) Distribution of sieve areas on the walls
   4) 1 & 3
2) A weak stemmed plant has leaf-opposed tendrils, in which organic solutes are translocated through
   1) Sieve plate with single perforations
   2) Sieve cell with many performations
   3) Sieve with many perforations
   4) Trachea with many perforations
3) Ontogenetically sieve tubes and companion cells are similar but they differ in
   1) Nature of protoplast 2) Origin
   3) Retention of nucleus 4) 1 & 3
4) The commercial products obtained from living conducting tissue is
   1) Phloem rays 2) Libriform fibres
   3) Secondary phloem fibres 4) Wood fibres
5) Callose is a
   1) Protein 2) Carbohydrate3) Fat 4) Organic acid
6) In the sieve tube, the cytoplasm exhibit slow streaming movements at the rate of
   1) 10mm/h in unidirectional 2) 3 – 5 cm/h in upward direction
   3) 3 –5 mm/h in bisectional 4) 3 –5 cm/h in upward and downward direction
7) The primary meristem which gives rise to secondary vascular tissues is
   1) Intercalary meristem 2) Interfasicular cambium
   3) Intrafasicular cambium 4) Vascular cambium
8) Cells are not grouped into tissue in
   1) Mosses 2) Ferns 3) Conifers 4) Colonial forms
9) Vessels are poorly developed in
   1) Drought resistant 2) Drought escapers
   3) Drought avoiders 4) Drought enduers
10) Common character in tracheids, vessels and xylem fibers are
    1) Lignified, thin walled and dead 2) Non-lignified, thick walled & living
    3) Lignified, thick of dicot stem 4) Hypodermis of monocot root
11) Continuous ring of living mechanical tissue is found in
    1) Hypodermis of dicot root 2) Hypodermis of monocot stem
    3) Hypodermis of dicot stem 4) Hypodermis of monocot root
12) Assertion: Collenchyma gives tensile strength
    Reason: The cell walls of collocytes are characteristically evenly thickened

a. A and R are correct, R is the correct explanation of A
b. A and R are correct, R is not the correct explanation of A
c. A is true but R is false
d. A is false but R is true

13) In the vascular bundle of the following plant xylem tissue is sand-witched between two patches of living conducting tissue
1) Thorn apple 2) Spanish dagger 3) Belladona 4) 1 & 3
14) Complementary cells is lenticels are
a. Loose mass of thin walled, suberised parenchyma
b. Loose mass of thin walled, non-suberised parenchyma
c. Loose mass of thick walled, non-suberised parenchyma
d. Compact mass of thin walled, non-suberised collenchyma
15) Collateral, conjoint and closed vascular bundles are found in
1) Dorsiventral leaf 2) Isobilateral leaf
3) Monocot stem 4) All
16) Type of laticifers found in diecious fruit yielding plant which show leaf mosaic
1) Simple laticifers 2) Articulated laticifers
3) Non articulated laticifer 4) Latex cells
17) Latex is an emulsion which contain the following characteristic components
1) Resins and gums 2) Rubber and alkaloids
3) Resins and rubber 4) Sterols and mucilage
18) Latex is commonly associated with
1) Dead conducting tissue 2) Living conducting tissue
3) Living mechanical tissue 4) ground tissue
19) Name an Aroideae member which contains hydathodes
1) Lycopersicon 2) Grasses 3) Colacasia 4) Triticum
20) Type of secretory cavities found in plant showing apical dominance
1) Resin ducts 2) Lysigenous cavity
3) Osmophores 4) Schizogenous cavity
21) In orchids, osmophores are associated with
1) Stamens 2) Sepals 3) Petals 4) Fruits
22) Modified assimilatory structures and non-modified assimilatory structures contain nectaries respectively
1) Nepenthes, passiflora 2) Passiflora, citrus
3) Nepenthes, drosera 4) Passiflora, Tridax
23) In Drosera digestive glands are present on
1) Pitcher 2) Tentacles 3) Leaf margin 4) Bladder
24) Resin ducts in Pinus are surrounded by
1) Endothecium 2) Epithem 3) Exothecium 4) Epithelium
25) Secondary growth in dicot root is due to activity of
1) Exodermis 2) Pith 3) Pericycle 4) Endodermis
26) Identify the correct statement
1) Radial VB are always endarch 2) Collateral VB are always open
3) Bicollateral VB are always open 4) Concentric VB are always open
27) Callose and slime accumulation on a sieve areas are chemically
1) Poly saccharide and protein 2) Poly saccharide and phospholipid
3) Protein and carbohydrate 4) Starch and organic acid
28) Tracheary plugs are
1) Simple plugs 2) Callose plugs

3) Tyloses 4) All

29) Hydrilla stem, Opuntia phylloclade and Viscum stem contain
1) Well developed vascular tissue 2) Poorly developed vascular tissue
3) Poorly developed vessels 4) Well developed vessels

30) The fruit bearing plant that conducts mineral water through tracheids only
1) Liriodendron 2) Selaginella
3) Trochodendron 4) Dracaena

31) A primary meristem that participate in intrastelar secondary growth in dicot stem is
1) Interfasicular cambia 2) Fasicular cambia
3) Vascular cambium 4) Phellogen

32) Sclereids are ramified in
1) Osteosclereids 2) Astrosclereids 3) Trichosclereids 4) All

33) Cortex represented by hypodermis in case of
1) Tridax 2) Helianthus root 3) Zea stem 4) Zea root

34) Endosperm cells of Secale contain
a. Parenchyma concerned with synthesis of food
b. Parenchyma gives buoyancy
c. Parenchyma helps in storage of food
d. Parenchyma helps in storage of water

35) Stem of Sambucus contain
a. Collenchyma with irregular arrangement of cells with collocytes
b. Sclerenchyma with regular arrangement of cells with collocytes
c. Collenchyma with regular arrangement of collocytes
d. 1 & 3

36) Drymis and Trochodendron are
1) Tracheidless angiosperms2) Vesseless angiosperms
3) Vesseless gymnosperms 4) Vesseless pteridophytes

37) Fibres are obtained from
1) Xylem, parenchyma, epidermis 2) Xylem, phloem, sclerenchyma
3) Xylem, phloem, collenchyma 4) Xylem, sclereids, collenchyma

38) Arrange the parts of hydathode sequentially from margin to centre
A) Water stomata B) Epithem C) Air cavity D) Vein ending
1) A B C D 2) A C D B 3) D B C A 4) A C B D

39) Laticifers possess
1) Lignified and elastic cell walls 2) Non-lignified and non-elastic cells walls
3) Non-lignified and elastic cell walls 4) Lignified and non-elastic cells walls

40) Guttation can be noticed in plants like
a. Colocasia, Lycopersicon, Pothos, Achras
b. Colacasia, Lycopersicon, Pothos, Tropeolum
c. Colacasia, Lycopersicon, Papever, Ficus
d. 1 & 2

41) Indian rubber is obtained from
1) Hevea brasiliensis 2) Ficus religiosa 3) Ficus elastica 4) Euphorbia

42) Resin ducts in Pinus is characterised by
a. Formed by the enlargement of inter cellular spaces
b. Formed by the lysis of secretory cells
c. Cells surrounding the cavity are called epithelium
d. 1 & 3

43) Simple sieve plate is found in

1) Cocos 2) Cucurbita 3) Carica 4) Carthamus

44) Chemical nature of slime and callose respectively
1) Carbohydrate and protein 2) Protein and carbohydrate
3) Protein and protein 4) Carbohydrate and lipids

45) Roots of angiosperms contain
1) Endarch xylem 2) Mesarch xylem
3) Exarch xylem 4) 1 & 2

46) Meristems are absent in
1) Datura 2) Funaria 3) Tridax 4) Oryza

47) Length of the plant is increased by
1) Lateral meristem 2) Fasicular cambium
3) Apical meristem 4) Vascular cambium

48) Tyloses are developed from
1) Ray parenchyma 2) Axial parenchyma
3) Companion cells 4) Libriform fibres

49) Water storage panchyma is abundant in
1) Hydrilla 2) Hibiscus 3) Agave 4) Casuarina

50) Unevently thickened cell walls are the typical feature of
1) Collocytes 2) Parenchyma 3) Aerenchyma 4) Sclereids

51) The growth of the plant due to intercalary meristems is
1) Linear 2) Radial 3) Transverse 4) Tangential

52) Open elongated and cylindrical dead cells with thick lignified walls are
1) Tracheae 2) Tracheids 3) Sieve tubes 4) Sieve cells

53) Branchy sclereids are also known as
1) Stone cells 2) Malpighian cells 3) Branched cells 4) Raphides

54) The term coined by Nageli is
1) Phloem 2) Xylem 3) Meristem 4) All the above

55) Phylogenetically cells which contain large number of chloroplasts are
1) Sieve cells 2) Tracheids 3) Sieve tubes 4) Fibres

56) Parenchymatous cells which contain large number of chloroplasts are
1) Aerenchyma 2) Collenchyma
3) Prosenchyma 4) Chlorenchyma

57) Tracheids are the main components of xylem in
1) Pteridophytes 2) Gymnosperms
3) Secondary xylem of Gymnosperms 4) All the above

58) Most primitive tracheophytes are
1) Bryophytes 2) Gymnosperms 3) Angiosperms 4) Pteridophytes

59) The vessel wall area bearing perforations is called
1) Sieve plate 2) Sieve area 3) Perforation plate 4) Tracheal plug

60) The parenchyma with radiating arms is
1) Aerenchyma 2) Chlorenchyma 3) Collenchyma 4) Transfer cells

61) It is a pure secondary meristem
1) Vascular cambium 2) Intercalary meristem
3) Intra fascicular cambium 4) Cork cambium

62) Simple mechanical tissue with non lignified walls is
1) Collenchyma 2) Chlorenchyma 3) Sclerenchyma 4) Aerenchyma

63) Both type of mechanical tissues are found in the aerial roots of
1) Olea 2) Mouriria 3) Leucas 4) Monstera

64) Usually the following tissue lies as hypodermis in aerial parts of dicots

1) Parenchyma 2) Xylem 3) Collenchyma 4) Cambium

65) Protoxylem is towards epidermis in
1) Root of monocot 2) Stem of monocot
3) Root of dicot 4) 1 & 3

66) Intercalary meristems are found at the base of
1) Root 2) Petiole 3) Internodes 4) Stipule

67) A gymnosperm with vessels is
1) Gnetum 2) Selaginella 3) Drymis 4) Tinospora

68) Vessel less angiosperm is
1) Datura 2) Derris 3) Drymis 4) Dracaena

69) Ladder like secondary thickenings in tracheary elements are called
1) Reticulate 2) Sclariform 3) Pitted 4) Spiral

70) Collenchyma differs from sclerenchyma in
1) Having a wide lumen 2) Retaining protoplasm at maturity
3) Uniform thick cells walls 4) Being meristematic

71) Most primitive tissue is
1) Collenchyma 2) Parenchyma 3) Sclereids 4) Fibres

72) Chief anatomical adaptation of hydrophytes is
1) Abundant sclerenchyma 2) Presence of aerenchyma
3) Presence of collenchyma 4) Highly developed xylem

73) These walls are excessively thickened in the collenchyma which are found in stems of Sambucus
1) Radial 2) Vertical 3) Tangential 4) Peripheral

74) Continuous collenchymaous hypodermis is found in this stem
1) Zea 2) Cucurbita 3) Drancaena 4) Helianthus

75) The tissue helps on healing of wounds, grafting and regenerating of lost plant parts is
1) Collenchyma 2) Parenchyma 3) Sclereids 4) Fibres

76) The sclereids are classified into six groups based on their
1) Size 2) Colour 3) Shape 4) Cell wall material

77) A group of dissimilar cells which work collectively as a single functional unit are called
1) Simple tissue 2) Complex tissue 3) Special tissue 4) Mechanical tissue

78) Highest percentage of water is present in the cell walls of
1) Collocytes 2) Parenchyma 3) Chlorenchyma 4) Sclerenchyma

79) Lateral meristem present in between the xylem and phloem of vascular bundle in primary structure is
1) Intrafascicular cambium 2) Interfascicular cambium
3) Cork cambium 4) Phellogen

80) Tyloses are formed
1) When xylem is injured 2) In sap wood
3) When sap wood is converted to heart wood 4) 1 & 3

81) Collenchyma with regular arrangement of collocytes is found in
1) Stem of Leucas 2) Stem of Datura
3) Aerial roots of Montera 4) Stem of Sambucus

82) Wood is formed by the activity of
1) Cork cambium 2) Periblem 3) Plerome 4) Vascular cambium

83) Cork cambium is an example of
1) Lateral meristem 2) Primary meristem
3) Secondary meristem 4) 1 & 3

84) True scelerenchymatous fibres showing simple pits are

1) Fibre tracheids 2) Tracheids
3) Libriform fibres 4) Tyloses

85) Internodes of grass stems elongate by the activity of
1) Apical meristem 2) Intercalary meristem
3) Secondary meristem 4) Lateral meristem

86) Collocytes can participate in
1) Providing flexibility 2) Exchange of gases
3) Photosynthesis 4) 1 & 3

87) In this plant all major functions are performed by parenchyma
1) Pteris 2) Cycas 3) Gnetum 4) Funaria

88) Intercellular spaces are found in this type of collenchyma
1) Lacunar 2) Angular 3) Lamellar 4) 2 & 3

89) The tissue which helps in exchange of gases and also buoyancy in aquatic plants
1) Parenchyma 2) Aerenchyma 3) Collencyma 4) All the above

90) The fibres of Linum are
1) Sclerenchyma fibres 2) Flax fibres
3) Phloem fibres 4) Xylem fibres

91) The cytoplasmic strands which are observed in sieve tubes under electron microscope appear as
1) Fibres 2) Conveyer belts 3) Callose 4) Slime plugs

92) Filiform sclereids are present in
1) Olea 2) Dolichos lab-lab 3) Nymphaea 4) Cocos nucifera

93) Example for compound sieve plate
1) Gnetum 2) Cucurbita 3) Vitis 4) 2, 3 both

94) The cavity formed due to enlargement of inter cellular space between secretory cells
1) Lysigenous cavity 2) Secretary cavities
3) Digestive glands 4) Schizogenous cavity

95) Special tissues in Euphorbia and Nerium
1) Non-articulated laticefers 2) Articulated laticifers
3) Simple laticifers 4) 1 & 3 both

96) In plants the structures which prevent the spreading of pathogenic fungi in xylem vessels are
1) Exarch xylem 2) Endarch xylem 3) Mesearch xylem 4) Tyloses

97) The tissue which gives flexibility and elasticity are present in plant parts like
1) Petioles 2) Peduncles 3) Hypodermis of dicots 4) All the above

98) In some gymnosperms instead of companion cells – are present
1) Petioles 2) Peduncles 3) Hypodermis of dicots 4) All the above

99) The nectar glands present in Passiflora are
1) Extra floral nectaries 2) Floral nectarines 3) Osmophores 4) Hydathodes

100) Example for the bast fibres which have high commercial value
1) Pisum sativum 2) Monstera
3) Corchorus capsularis 4) Olea

101) Living cells of xylem and dead cells in Phloem
1) Tracheids and Companion cells 2) Xylem parenchyma and Phloem fibres
3) Xylem vessels and sieve elements 4) Xylem fibres and companion cells

102) Guttation takes place in the following plants
1) Colocasia, Lymcopersicon 2) Pothos, Tropaeolum
3) Ficus, Cannabis 4) 1, 2 Both

103) The tissue which help in conduction of organic solutes from the leaves to the other parts of the plant body

1) Bast 2) Leptome 3) Phloem 4) All the above

104) First formed primary xylem is called
1) Protoxylem 2) Metaxylem 3) Exarch 4) Endarch

105) The true fibres associated with xylem is called as
1) Bast fibres 2) Libriform fibres 3) 1 & 2 4) Xylem parenchyma

106) The Perforated cross walls in sieve tubes are called
1) Sieve pores 2) Sieve cells 3) Sieve plate 4) Callose plug

107) Plant with complex tissues are included in
1) Bryophyta 2) Sugars 3) Alkaloids 4) All the above

108) Latex is an emulsion of
1) Proteins 2) Sugars 3) Alkaloids 4) All the above

109) Resin ducts in Pinus is
1) Schizogenous cavity 2) Lysigenous cavity
3) Schizolysigenous cavity 4) Hydathode

110) In Passiflora extrafloral nectaries are present on
1) Petiole 2) Flowers 3) Stem 4) Stipules

111) Water stomata is present in
1) Hevea 2) Lycopersicon3) Ficus4) Eucalyptus

112) The cells that originate from common mother cells in phloem are
1) Phloem fibres and parenchyma
2) Companion cells & Phloem parenchyma
3) Sieve tube elements & companion cells
4) Sieve tube elements & phloem fibres

113) Free nuclear divisions occur in
1) Latex cells, Latex vessels, Perisperm
2) Latex cells and during embryosac formation
3) Latex cells, Latex vessels & embryo formation
4) Latex cells, vessels, medulla formation

114) Which is true to Meristem?
1) Intercellular spaces present 2) Cell walls are not cellulosic
3) These are persistent embryonic tissues 4) Ergastic substances present

115) Dedifferentiated permanent tissues is
1) Primary meristem 2) Secondary meristem
3) Apical meristem 4) Intercalary meristem

116) Which of the following is ephemeral?
1) Apical meristem 2) Cork meristem
3) Intercalary meristem 4) Vascular meristem

117) Which of the following shows division of labour?
1) Fundamental tissue of lower plants 2) Ground tissue of lower plants
3) Ground tissue of higher plants 4) Collenchyma of higher plants

118) Uneven thickening of cell walls seen in
1) Epidermis of Helianthus 2) Hypodermis of Helianthus
3) Epidermis of cucurbita 4) Hypodermis of Zea

119) Type of collenchyma seen in a plant with head inflorescence
1) Angular 2) Lamellar 3) Parenchyma 4) Lacunar

120) Tensile strength and hardness giving tissue in a plant are
1) Meristems and Parenchyma 2) Parenchyma and Collenchyma
3) Collenchyma and Sclerenchyma 4) Sclerenchyma and Meristems

121) The tissues not seen in Thallophyta

1) Simple tissue 2) Complex tissue 3) Parenchyma 4) All the above

122) A student observing a slide having a cell with ladder like depositions in cell wall. What is the tissue?
1) Metaxylem 2) Complex tissue 3) Parenchyma 4) All the above

123) The main conducting elements of Trochodendron
1) Trachea 2) Tracheids 3) Vessels 4) Xylem parenchyma

124) Mature Tyloses cell wall shows
1) Cellulose 2) Hemi cellulose 3) Pectin 4) Lignin

125) Commercially valuable part of Jute
1) Primary phloem 2) Secondary xylem
3) Secondary phloem 4) Wood

126) Every cell performs all functions in all
1) Apical meristem 2) Fascicular meristem
3) Intercalary meristem 4) Cork cambium

127) Every cell performs all functions in all
1) Prokaryotes & Eukaryotes 2) Unicellular forms & Colonial forms
3) Thallophytes and bryophytes 4) Unicellular forms only

128) The primary structures of the plant body are derived by
1) Vascular cambium 2) Secondary meristems
3) Apical meristems 4) Intercalary meristems

129) Select the incorrect pair
1) Angular collenchyma – stems of Datura
2) Lacunar collenchyma – stems of Leucas
3) Lamellar collenchyma – aerial roots of Sambucus
4) Aerenchyma – stems of hydrilla

130) Embrophytic, non-archegoniatic trachaeophyta are the
1) Phanerogams 2) Angiosperms
3) Pteriodophytes & phanerogams 4) All Eukaryotes

131) The injury of the sieve tube is indicated by
1) Disappearance of nucleus 2) Deposition of lignin in the cell wall
3) Presence of slime plugs 4) Presence of callose plugs

132) The following are generally absent in monocot stems and leaves
1) Sclerenchyma & apical meristems 2) Collenchyma & lateral meristems
3) Parenchyma & secondary meristems 4) Phloem & xylem

133) Callose is a type of
1) Protein 2) Lipid 3) Carbohydrate 4) Alkaloid

134) In angiosperms the main channels responsible for the conduction of water and food materials respectively are
1) Tracheids & sieve cells 2) Phloem & xylem
3) Xylem vessels & sieve tubes 4) Sieve tubes & xylem vessels

135) Orchids contain
1) Nectar glands 2) Digestive glands 3) Hydathodes 4) Osmophors

136) In lamellar collenchyma
1) Tangential walls are thick and radial walls are thin
2) Tangential walls are thin and radial walls are thick
3) Both tangential walls and radial walls are thick
4) Thickenings are confined to the walls bordering intercellular spaces

137) Assertion: Sieve tube elements and companion cells are ontogenetically identical
Reason: They arise from a common meristematic cell

1) A and R are true, R is the correct explanation of A
2) A and R are true, R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

138) Select the incorrect pair
1) Libriform fibres – simple pits
2) Fibre tracheids – bordered pits
3) Tracheids – presence of perforations at their tapering ends
4) Poorly developed xylem vessels – succulents

139) According to the committee on nomenclature of tracheary elements
1) Metaxylem elements are larger with pitted secondary walls
2) Metaxylem elements are larger with scariform, reticulate secondary walls
3) Protoxylem elements are smaller with pitted secondary walls
4) Protoxylem elements are larger with spiral secondary walls

140) Protoxylem is the centre occupied on either side by metaxylem is found in
1) Mosses 2) Ferns
3) Roots of angiosperms 4) Stems of gymnosperms

141) Ontogentically related pair is
1) Companion cell – Albuminous cell 2) Tracheid – Vessel
3) Sieve tube – companion cell 4) Sieve cell – Sieve tube

142) Linear growth of the plant body is due to
I) Apical meristem II) Intrafasicular cambium
III) Phellogen IV) Inter calary meristem
1) I only 2) I & IV 3) I & III 4) II & IV

143) Select the true statement
I) All secondary meristems are generally lateral
II) All lateral meristems are secondary
III) All apical meristems are primary
IV) Phellogen is purely composed of secondary mechanism
V) Vascular cambium is composed of secondary meristem only
1) I, III, IV 2) I & V 3) I, III, V 4) II, III, IV

144) Two types of mechanical tissues without protoplasts are found in
I) Aerial roots of monstera II) Leaves of olea
III) Stems of Sambucum IV) Leaf of Nymphaea
1) I & II 2) I only 3) II only 4) III & IV

145) Study the following:

List –I	List –II
A) Drimys	I) A first tracheophyte with vessel
B) Opuntia	II) Vessels and tracheids absent
C) Mangifera	III) Vessels poorly developed
D) Selaginella	IV) Vesselless angioisperm
	V) Vessels well developed

1) A-I, B-II, C-III, D-IV 2) A-IV, B-III, C-I, D-V
3) A-IV, B-III, C-V, D-I 4) A-V, B-IV, C-III, D-II

146) Assertion: The older wood gradually converts into alburnum and newly formed secondary xylem transform into duramen
Reason: With the increase in the ago of the tree, the wood undergoes a number of physical and chemical changes
1) A and R are true, R is the correct explanation of A

2) A and R are true, R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

147) Identify the incorrect statements related to vascular cambium
1) It is formed by the union of primary and secondary lateral meristems
2) It contain two types of initiating cells
3) Generally it produces more about of living conducting tissue than the dead conducting tissue
4) It divides periclinally and produces both secondary vascular tissues and vascular rays

148) Assertion: In grass stem, bundle sheath cells are homologous to endodermis
Reason: In grass leaf, border parenchyma possess casparian strips on their walls
1) A and R are true, R is the correct explanation of A
2) A and R are true, R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

149) A) Water Stomata B) Vein ending C) Epithem
D) Epithelium E) Air Cavity
1) B, C, E, A 2) B, D, E, A 3) A, B, C, D 4) E, B, C, D

150) Secondary growth in dicot root is due to activity of
1) Exodermis 2) Pith 3) Pericycle 4) Endodermis

151) Identify the suberized zones
A) Endodermis of monocot stem
B) Exodermis of monocot root
C) Endodermis (except passage cells) of dicot root
D) Outer part of old dicot stem
1) B, C, D 2) A, B, C 3) B, A, D 4) A, C, D

152) Assertion: All tracheophytes contain both trachelds and vessels
Reason: According to Dixon, trachids are more efficient water conducting channels
1) A and R are true, R is the correct explanation of A
2) A and R are true, R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

153) Assertion: Albuminous cells and companion cells are analogous structures
Reason: The sieve tube elements and companion cells are not related ontogenetically
1) A and R are true, R is the correct explanation of A
2) A and R are true, R is not the correct explanation of A
3) A is true, but R is false
4) A is false, but R is true

154) Assertion: The structure of wall is the most distinctive feature of collenchyma
Reason: The thickenings are deposited are excessively thickened due to greater accumlation of cellulose and pectin
1) A and R are true, R is the correct explanation of A
2) A and R are true, R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

155) Study the following and select the correct match
I) Living non-mechanical tissue - Collenchyma

II) Non-elastic mechanical tissue - Sclerenchyma
III) Non-lignified mechanical tissue - Collenchyma
IV) Living, primitive tissue - Parenchyma
1) I & IV 2) III & IV 3) II, III & IV 4) I, II & IV

156) Endosperm of Secale contain
1) Chlorenchyma 2) Aerenchyma
3) Storage parenchyma 4) 1 & 3

157) Study the following table:

List – I (Name of the plant)	List –II (Type of sclereids)
A) Petioles of water lily B) Aerial Monstera root C) Leaves of Hakea D) Testa of Pisum	I) Astro II) Macro III) Tricho IV) Osteo

1) A-I, B-III, C-IV, D-II 2) A-I, B-III, C-II, D-IV
3) A-I, B-II, C-III, D-IV 4) A-IV, B-III, C-II, D-I

158) Assertion: The sieve tube elements and companion cells are related ontogenetically
Reason: They originate from different meristematic cells
1) A and R are true, R is the correct explanation of A
2) A and R are true, R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

159) Study the following table:

List –I (Name of plant)	List –II Type of sclereids	List –III Part of the plant
I) Hakea II) Pisum sativum III) Monstera IV) Olea	Osteosclereids Malpighian cells Filiform Filiform	Cotyledons Seeds Aerial roots Leaves

Which two show correct combination?
1) II & IV 2) I & II 3) III & IV 4) I & IV

160) Match the following:

List –I	List –II
A) Musa B) Agave C) Lactuca D) Sambucus	I) Lamellar collenchyma II) Lacunar collenchyma III) Aerenchyma IV) Water storage parenchyma

1) A-I, B-II, C-IV, D-III 2) A-III, B-IV, C-I, D-II
3) A-III, B-IV, C-II, D-I 4) A-II, B-IV, C-III, D-I
1) III & IV 2) I & III 3) II & IV 4) II & III

Keys
Ex – 1

1)4	2)3	3)4	4)3	5)2	6)4	7)3	8)4	9)3	10)4
11)3	12)3	13)4	14)2	15)4	16)2	17)3	18)2	19)3	20)2
21)3	22)1	23)2	24)4	25)3	26)3	27)1	28)3	29)3	30)3
31)2	32)4	33)3	34)3	35)3	36)2	37)2	38)4	39)3	40)2
41)3	42)4	43)2	44)2	45)3	46)2	47)3	48)2	49)3	50)1

51)1	52)1	53)2	54)4	55)2	56)4	57)4	58)4	59)3	60)1
61)4	62)1	63)4	64)3	65)4	66)3	67)1	68)3	69)2	70)2
71)2	72)2	73)3	74)2	75)2	76)3	77)2	78)1	79)1	80)4
81)4	82)4	83)4	84)3	85)2	86)4	87)2	88)1	89)2	90)2
91)2	92)1	93)3	94)4	95)3	96)4	97)4	98)2	99)1	100)3
101)2	102)4	103)4	104)1	105)2	106)3	107)4	108)4	109)1	110)1
111)2	112)3	113)2	114)3	115)2	116)3	117)3	118)2	119)4	120)3
121)2	122)1	123)2	124)4	125)3	126)4	127)2	128)3	129)3	130)2
131)3	132)2	133)3	134)3	135)4	136)1	137)1	138)3	139)1	140)2
141)3	142)2	143)1	144)3	145)3	146)4	147)3	148)1	149)1	150)3
151)1	152)4	153)3	154)1	155)3	156)3	157)1	158)3	159)1	160)3

ANATOMY

Ex – 1

1) The epidermal cell that gives rise to the root hair is called
   1) Collocyte 2) Trichoblast 3) Idioblast 4) Rhizoblast
2) Epiblema is
   1) Hypodermis made up of continuous sclerenchyma
   2) Hypodermis made up of continuous collenchyma
   3) Cuticle layer on the surface of epidermis
   4) The root epidermis with root hairs
3) Root hair is
   1) Unicellular 2) Uniseriate 3) Multicellular 4) Biseriate
4) Root hairs absorb the following water from the soil
   1) Hygroscopic 2) Run away 3) Capillary 4) Gravitational
5) Assertion: Root hairs are not trichomes
   Reason: Root hairs are tubular extensions of epidermal cells but not out growths
   1) A and R are true, R is the correct explanation of A
   2) A and R are true, R is not the correct explanation of A
   3) A is true but R is false
   4) A is false but R is true
6) Arrange the following centrifugally in the root
   A) Endodermis B) Exodermis C) Medulla D) Epidermis
   E) General Cortex
   1) DBEAC 2) CAEBD 3) DBCEA 4) CAEDB
7) Suberin is found in the cell walls of
   I) Endodermis II) General Cortex III) Exodermis IV) Epidermis
   1) III only 2) III, IV 3) I, II, IV 4) I, III
8) Assertion: Cortex is relatively bigger in monocot root than that of dicot root
   Reason: Roots contain radial or separate vascular bundles
   1) A and R are true, R is the correct explanation of A
   2) A and R are true, R is not the correct explanation of A
   3) A is true but R is false
   4) A is false but R is true
9) Caparian thickenings are made up of
   A) Suberin B) Pectin C) Lignin D) Chitin
   1) A, C 2) A, B 3) B, C 4) C, D

10) Endodermal cells without casparian bands are called
1) Trichoblasts 2) Collocytes 3) Passage cells 4) Idioblasts
11) Identify the incorrect regarding passage cells
1) They are opposite to protoxylem elements
2) Cell walls are thin
3) Casparian bands are absent
4) They help in entry of water and mineral salts from stele to cortex
12) Stele is smaller than cortex in
1) Dicot root 2) Monocot root 3) Dicot stem 4) 1 & 2
13) Outer most part of the stele is
1) Endodermis 2) Conjunctive tissue 3) Pericycle 4) Medulla
14) Assertion: Lateral roots are endogenous in origin
Reason: Lateral roots develop fro pericycle
1) A and R are true, R is the correct explanation of A
2) A and R are true, R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true
15) Function of pericycle in dicot root is
A) Production of lateral roots
B) Production of vascular cambium during secondary growth
C) Production of cork cambium during secondary growth
D) Mechanical support
1) ABC 2) A only 3) BC only 4) ABCD
16) Study the following and identify the correct match

List –I	List –II
A) Castanea	I) Triarch
B) Pisum sativum	II) Diarch
C) Trapa natans	III) Pentarch
D) Nictoiana tabacum	IV) Octarch
E) Ricinus communis	V) Monarch

1) A-IV, B-I, C-V, D-III, E-II 2) A-V, B-I, C-IV, D-II, E-III
3) A-V, B-I, C-IV, D-III, E-II 4) A-IV, B-I, C-V, D-II, E-III
17) The parenchymaymatous ground tissue that extends between xylem and phloem strands is called
1) Conjunctive tissue 2) Medullary ray 3) Medulla 4) Pericycle
18) Idenfity the correct statement regarding medulla of dicot root
A) It is well developed B) It helps in the storage of food and water
C) It is parenchymatous D) It is small or may be completely absent
19) Velamen roots contain
1) Multiple epidermis 2) Velamen tissue 3) Hygroscopic nature 4) All the above
20) Velamen roots are found in
1) Liliaceae 2) Orchidaceae 3) Asteraceae 4) Cucurbitaceae
21) Assertion: Monocot root endodermis contains more passage cells than that of dicot root
Reason: Monocot root exhibits polyarch condition
1) A and R are true, R is the correct explanation of A
2) A and R are true, R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true
22) Identify the correct regarding pericycle of monocot root

I) In old and mature roots, the pericycle is sclerechymatous
II) It will not produce vascular cambium
III) It gives rise to lateral roots
IV) It is parenchymatous
1) I, II, IV only 2) I, II, III only 3) I, II, III, IV 4) III, IV only

23) Xylem in monocot root is
1) Polyarch 2) Exarch 3) Endarch 4) Both 1 & 2

24) Epidermis of dicot stem differs from that of monocot stem by living
A) Trichomes B) Stomata C) Cuticle D) Motor cells
1) A only 2) AB 3) ABC 4) BCD

25) In sunflower stem cortex is
1) Larger than stele 2) Equal to stele
3) Small than stele 4) Smaller than epidermis

26) Hypodermis is Helianthus stem is made up of
1) Continuous sclerenchyma 2) Discontinuous collenchyma
3) Discontinuous sclerenchyma 4) Continuous collenchyma

27) In dicot stem resin ducts are found in
1) Medulla 2) General cortex 3) Hypodermis 4) Stele

28) Function of general cortex in dicot stem is
1) Synthesis of food 2) Mechanical support
3) Storage of food 4) Both 1 & 3

29) Assertion: In dicot endodermis is called starch sheath
Reason: In dicot endodermis synthesizes starch grains
1) A and R are true, R is the correct explanation of A
2) A and R are true, R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

30) The following are absent in the endodermis of dicot stem
1) Lignin 2) Suberin 3) Passage cells 4) Starch grains

31) Pericycle in Helianthus stem is
A) Heterogeneous B) Made up of discontinuous scierenchyma
C) Having semi lunar patches of sclerenchyma
E) Providing mechanical strength
1) BCD only 2) CD only 3) C only 4) ABCD

32) Assertion: In Helianthus stem the pericycle is heterogeneous
Reason: In Helianthus stem pericycle is made up of sclerenchyma with intervening masses of parenchyma
1) A and R are true, R is the correct explanation of A
2) A and R are true, R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

33) Stele in dicot stem is
1) Atactostele 2) Eustele 3) Dictostele 4) Plectostele

34) Shape of vascular bundle in dicot stem is
1) Wedge or top 2) Oval 3) Semilunar 4) Falcate

35) Vascular bundle in dicot stem is
1) Conjoint 2) Collateral 3) Open 4) All the above

36) The chief function of medulla in dicot stem is
1) Mechanical support 2) Storage of food materials

3) Production of vascular cambium 4) Carbon assimilation

37) A dicot stem consists of 18 vascular bundles. Total number of medullary rays in that stem is
1) 18 2) 19 3) 17 4) 36

38) Assertion: T.S. of monocot stem cannot be divided into epidermis, cortex and stele
Reason: In monocot stem numerous vascular bundles are irregularly scattered in the ground tissue
1) A and R are true, R is the correct explanation of A
2) A and R are true, R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

39) Monocot stem differs from dicot stem by lacking
1) Stomata 2) Cuticle 3) Epidermis 4) Trichomes

40) Hypodermis is monocot stem is made up of
1) Continuous collenchyma 2) Discontinuous sclerenchyma
3) Continuous sclerenchyma4) Discontinuous collenchyma

41) Structures absent in monocot stem are
A) Pericycle B) Endodermis C) Trichomes D) Medullary rays
1) AB only 2) ABC only 3) CDE only 4) ABCDE

42) Bulk of monocot stem is occupied by
1) Ground tissue 2) Hypodermis 3) Epidermis 4) Vascular bundles

43) Assertion: In monocot stem vascular bundles are called fibro vascular bundles
Reason: In monocot stem, each vascular bundle is enclosed by a sheath which is made up of sclerenchymatous fibres
1) A and R are true, R is the correct explanation of A
2) A and R are true, R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

44) Vascular bundle in monocot stem is
1) Conjoint 2) Collateral 3) Closed 4) All the above

45) Stele in monocot stem is
1) Eustele 2) Atactostele 3) Dictyostele 4) Solenostele

46) Arrangement of xylem vessels in the fibro vascular bundle is
1) Serial order 2) ‘V’ shape3) ‘Y’ shape 4) ‘L’ shape

47) Function of protoxylem lacuna is
1) Storage of food 2) Storage of gases
3) Secretion of enzymes 4) Storage of water

48) Protoxylem lacuna is formed by crushing of
1) Protoxylem vessels 2) Metaxylem vessels 3) Sieve tubes 4) Xylem fibres

49) Phloem parenchyma is absent in
1) Dicot stem 2) Dicot leaf 3) Dicot root 4) Monocot stem

50) Conjunctive tissue is absent in
1) Monocot stem 2) Dicot stem 3) Dicot leaf 4) All the above

51) Identify the incorrect statement regarding dorsiventral leaf
1) Stomatal frequency is more on adaxial surface
2) Multicellular hairs are found on both upper & lower epidermis
3) Stomatal frequency is more on abaxial surface
4) Adaxial surface is dark green in colour

52) Assertion: Adaxial surface is dark green and abaxial surface is light green in dorsiventral leaf

Reason: In dorsiventral leaf palisade parenchyma is found beneath the upper epidermis and spongy parenchyma towards the lower epidermis

1) A and R are true, R is the correct explanation of A
2) A and R are true, R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

53) Primary function of spongy parenchyma is
1) Photosynthesis 2) Mechanical support
3) Exchange of gases 4) Conduction of materials

54) Vascular bundle in dicot leaf is
1) Conjoint 2) Collateral 3) Closed 4) All the above

55) Function of bundle sheath extensions in dicot leaf is
1) Mechanical support 2) Exchange of gases
3) Conduction of food from mesophyll to vascular
4) Carbon assimilation

56) Identify the characters of monocot leaf epidermis
1) Trichomes are absent
2) Stomatal frequency is equal on both surfaces
3) In gases bulliform cells are found in both surfaces
4) Cuticle is found on both surfaces

57) Motor cells are
1) Thin walled 2) Hygroscopic 3) Chlorenchymatous 4)1 & 2

58) Assertion: In grasses, bundle sheath cells are homologous to endodermis
Reason: In grasses bundle sheath cells posses casparian strips on their walls
1) A and R are true, R is the correct explanation of A
2) A and R are true, R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

59) Number of layers found in the bundle sheath of maize leaf is
1) 2 2) 4 3) Many 4) 1

60) Dicot leaf differs from monocot leaf with respect to
1) Position of Xylem 2) Position of Phloem
3) Differentiation of mesophyll 4) All the above

61) Secondary growth is absent in
A) Pteridophyta B) Gymnosperms C) Dicots D) Monocots
1) A, B 2) A, D 3) B, D 4) C, D

62) Anomalous secondary growth is found in
1) Yucca 2) Oryza 3) Dracaena 4) 1 & 3

63) In dicots secondary growth is found in
1) Root 2) Stem 3) Leaf 4) 1 & 2

64) Secondary growth is absent in
A) Hydrophytes B) Bryophytes C) Monocots D) Pteridophytes
1) Except ‘A’ 2) B D only 3) C D only 4) ABCD

65) Vascular cambium is
I) Lateral II) Completely primary
III) Completely secondary IV) Pteridophytes
1) I, IV 2) I, II 3) I, III 4) I only

66) Inter fascicular cambium is formed by
1) Medulla 2) Medullary ray 3) Cortex 4) Hypodermis

67) Inter fascicular cambium is
1) Primary 2) Secondary 3) Lateral 4) 2 & 3
68) First step in intrastelar changes is
1) Formation of fascicular cambium
2) Formation of cork cambium
3) Formation of vascular cambium
4) Formation of interfascicular cambium
69) Products of vascular cambium are
A) Secondary pheloem B) Cork
C) Phelloderm D) Secondary xylem
1) AB 2) CD 3) AD 4) BC
70) Secondary phloem is also known as
1) Hardbast 2) Bast 3) Wood 4) Phellem
71) Assertion: Vascular cambium is partly primary and partly secondary.
Reason: Interfascicular cambium is primary and intrafascicular cambium is secondary
1) A and R are true, R is the correct explanation of A
2) A and R are true, R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true
72) Fusiform initials and ray initials are found in
1) Vascular cambium 2) Phellogen 3) Phelloderm 4) Phellem
73) Bast ray and wood ray together called
1) Rhytidome 2) Periderm 3) Medullary ray 4) Vascular ray
74) Growth rings are formed in these regions
A) Cold B) Tropical C) Temperate D) Sea shore
1) A, B 2) B, C 3) A, C 4) B, D
75) The following is influenced by seasonal variations
1) Phellogen 2) Vascular cambium
3) Secondary Xylem 4) Phelloderm
76) ‘Spring wood’ or ‘early wood’ consists of
1) More number of xylem vessels 2) Vessels with wider lumens
3) Vessels with protoplasts 4) 1 & 2
77) The branch of science, which determines the approximate age of tree by counting the number of annual rings is called
1) Dendrochronology 2) Dendrology 3) Limnology 4) Arboriculture
78) Identify the correct statement
1) Latewood and early wood form in the same calender year
2) Late wood and early wood form alternate to each other
3) Late wood and early wood formed in an year together constitutes ‘growth ring’ or ‘annual ring’
4) All the above
79) Early wood differs from late wood with respect to
I) Origin II) Number of vessels III) diameter of lumen
1) I only 2) II, III3) II only 4) III only
80) Pseudo annual rings are formed due to
1) Diseases 2) Heavy leaf fall 3) Hormonal changes 4) All the above
81) Assertion: In tropical countries annual rings do not appear clearly
Reason: Seasonal variations are not sharp in tropical countries
1) A and R are true, R is the correct explanation of A

2) A and R are true, R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

82) The Changes occur in the wood of tropical trees are called
1) Growth rings 2) Pseudo annual rings
3) False annual rings 4) Growth marks

83) Assertion: The older xylem (Heart wood) present in the centre appears dark in colour
Reason: The older wood becomes infiltrarted with various organic compounds like oils, gums, resins, tannins, colouring agents and aromatic substances
1) A and R are true, R is the correct explanation of A
2) A and R are true, R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

84) Duramen is
1) Dark in colour 2) Very hard 3) Durable 4) All the above

85) Assertion: Duramen is non functional in conducting water
Reason: Tyloses grow into the lumens of vessels in heart wood
1) A and R are true, R is the correct explanation of A
2) A and R are true, R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

86) The peripheral, light coloured, functional wood is called
1) Alburnum 2) Duramen 3) Heart wood 4) Hard bast

87) Identify the incorrect regarding wood
1) Thickness of sap wood remains constant
2) Thickness of heat wood increases with increasing age
3) As time passes on, the sap wood gradually changes into heart wood
4) Sap wood is dark in colour

88) Alburnum lies in between
1) Secondary phloem and vascular cambium
2) Heart wood and vascular cambium
3) Secondary phloem and phellogen
4) Phelloderm and phellogen

89) Number of annual rings
1) Decreases from base to apex of the stem
2) More in the trunk than its branch
3) It Maximum at the base of the trunk
4) All the above

90) Periderm is formed by
A) Phellem B) Phelloderm C) Phellogen D) Secondary Phloem
1) A B only 2) B C only 3) A B C 4) A B C D

91) Function of periderm is
1) Protection 2) Mechanical support 3) Conduction of food 4) Conduction of water

92) Identify the correct statement
A) Phellogen produces more cells towards periphery
B) Vascular cambium produces more secondary xylem than secondary phloem
C) Vascular cambium and phellogen both undergo periclinal divisions
D) Both vascular cambium and phellogen produce cells towards centre and

periphery
1) A only 2) A B C D 3) B D only 4) A B C only
93) Assimilatory part in the secondary structure of dicot stem is
1) Phelloderm 2) Phellem 3) Phellogen 4) Secondary phloem
94) Cork cells without suberin are called
1) Phellem 2) Complimentary cells
3) Phelloids 4) Lenticels
95) Superior quality commercial cork is obtained from
1) Quisqualis indica 2) Quercus suber
3) Quamoclit phornicea 4) Terminalia catappa
96) Lenticels promote
1) Transpiration 2) Exchange of gases
3) Assimilation of Carbon 4) 1 & 2
97) Bark includes
A) Phellem B) Secondary phloem C) Phelloderm D) Phellogen
1) A B only 2) B C D only 3) B C only 4) ABCD
98) Innermost part of bark is
1) Secondary phloem 2) Vascular cambium
3) Secondary cortex 4) Secondary Xylem
99) Assertion: Cork tissue is impervious to water and gases
Reason: The cell walls of cork tissue are thickened with a waxy substance called suberin
1) A and R are true, R is the correct explanation of A
2) A and R are true, R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true
100) Periderm and secondary phloem together constitutes
1) Rhytidome 2) Bark 3) Cork 4) Lenticel

Keys

Ex –1

1)2	2) 4	3)1	4)3	5)1	6)2	7)4	8)2	9)1	10)3
11)4	12)4	13)3	14)1	15)1	16)4	17)1	18)2	19)4	20)2
21)1	22)3	23)4	24)1	25)3	26)4	27)2	28)4	29)3	30)3
31)4	32)1	33)2	34)1	35)4	36)2	37)1	38)1	39)4	40)3
41)4	42)1	43)1	44)4	45)2	46)3	47)4	48)1	49)4	50)4
51)1	52)1	53)3	54)4	55)3	56)2	57)4	58)1	59)4	60)3
61)2	62)4	63)4	64)4	65)1	66)2	67)4	68)4	69)3	70)2
71)3	72)1	73)4	74)3	75)2	76)4	77)1	78)4	79)2	80)4
81)1	82)4	83)1	84)4	85)1	86)1	87)4	88)2	89)4	90)3
91)1	92)2	93)1	94)3	95)2	96)4	97)4	98)1	99)1	100)2

UNIT – VII
ECOLOGY & ENVIRONMENT

1. Ecology or Environmental Biology: Relationship between organism and their biotic and physical surroundings.
2. Autecology or Species ecology: Relationship between organisms of same species or populations and their environment.
3. Synecology or Ecology of communities: Relationship between organisms of different species or populations.
4. Reasons for loss of ecological balance: Over utilization of physical resources, habitat alteration and destruction, over exploitation etc.
5. Diameter of earth: Approximately 12, 742 km.
6. Physical components of earth.
   A) Atmosphere – Gaseous envelop surrounding earth.
      a) Troposphere
         i) 8 to 10 kms above the earth surface at poles.
         ii) 16 to 18 kms above the earth surface at equator.
         iii) It extends upto tropopause.
         iv) Densest (75% of mass) and most turbulent layer.
         v) Temperature at tropopause decreases to 57^oC.
         vi) Percentage composition of a gas is same at all altitudes.
         vii) Partial pressure of gas changes with altitude.
         viii) Average atmospheric pressure on earth surface= 1014 millibars.
      b) Stratosphere :
         i) Upto 50 to 55 km above earth surface.
         ii) Contains ozone shield that absorbs U.V. rays to protect organisms.
         iii) Temperature increases with altitude.
      c) Ionosphere:
         i) From 50 to 500 km.
         ii) Mesosphere: 50 to 80 km, temperature decreases with altitude.
         iii) Thermosphere: 80 to 500 km, U.V. radiations cause ionization.
         iv) Reflects shorter radiowaves making telecommunication possible.
      d) Exosphere: outer space, atmospheric pressure extremely low.
   B) Hydrosphere :
      i) Liquid component, polar ice caps.
      ii) 71% of earth surface (97% sea water, 3 % fresh water).
   C) Geological layers: Solid component.
      a) Lithosphere – 0 to 60 km.
         i) Crust -
            - 0 to 35 km.
            - Ca, Na, Al silicates present.
         ii) Surface layer (few cms to few mts) → loose soil → rich in Organisms.
         iii) Upper most part of mantle – 35 to 60 km, composed of cold and strong material. It cools by **conduction.**
      b) Mantle - i) 35 to 2900 km, 70% of earth volume.

ii) Hard rocks (Fe and Mg).
iii) Temp = 100^o C (at upper boundary) to 4000^o C (core boundary).
iv) It cools by **convection** called as **asthenosphere.**

c) Core – 2900 to 6900 km.
   i) Outer core–4000^oC, liquid or molten Fe and Ni, radius beyond inner core=3478 km.
   ii) Inner core–6300^oC, solid, crystalline, Fe and Ni, radius =1278 km.

7. Environment: Sum total of all biotic and abiotic factors.
   A) Climate: Average weather of an area over a long period.
      a) Weather –Temperature, pressure, humidity, rainfall, sun shine, cloud cover, wind etc. at a given place and time.
      b) Temperature and rainfall are most important factors.
      c) Influence the distribution of living organisms.
      d) Climatic zones- i) Tropical - 0^o to 20^o latitude.
         ii) Sub tropical - 20^o to 40^o latitude.
         iii) Temperate - 40^o to 60^o latitude.
         iv) Polar - 60^o to 80^o latitude.
   B) Micro climate – Climate in the immediate surroundings of plants and animals.
   C) Habitat – Place where organisms live
   D) Ecological Niche - Functional role of an organism i.e., how it behaves, responds to its physical and biotic environments, its activities and interactions with other organisms in a biotic community.

8. Hierarchy among Living Organism

A. Organism – Basic unit of study in ecology.
B. Population – Group of organisms of single species in a particular area.
C. Biotic community – Assemblage of populations of different species of micro organisms, plants e.g. woodland community.
D. Landscape – Unit of land having a mosaic of ecosystems surrounded by natural boundaries.
E. Biomes – All biotic communities in a large area in particular climatic conditions. e.g.
   a) Tundra (treeless ground) – In arctic region.
   b) Taiga (coniferous forest) – In temperate region.
   c) Rain forests – In tropical regions.
   d) Grass lands.
   e) Deserts.
F. Biosphere or Ecospheres –
   a) Large global ecosystem with many different ecosystems.
   b) Total supporting environment (few meters above and below earth surface).
G. Ecosystem – Basic functional unit of biosphere. It is the self sustained unit.

a)
- Structural component
  - Abiotic factors
    - Physical factors: rainfall, light, temperature,
    - Chemical factors: Salinity, acidity, alkalinity, inorganic
  - Biotic factors
    - Producers
    - Consumers
    - Decomposers

b) Functional component { Flow of energy. Cycling of nutrients.

9. Abiotic Factors:

A) Light:

a) Chief source – Sun.
b) Radiant energy is in the form of electromagnetic waves.
c) Wave length of visible light or spectrum = 360nm to 760nm.
d) Solar constant – Average density of solar radiation measured outside earth's atmosphere.
e) 1/50 millionth part reaches upper layer of atmosphere (1.9 g.cal./cm^2/min)
f) 45% of above reaches on earth surface.
g) Insolation – Incoming solar radiation that reaches earth's surface.
It depends on i) angle of incidence ii) length of day & iii) absorption of light rays by different layers of atmosphere.
h) Albedo - Radiation reflected.
i) Only 51% sunlight (of all that passes through atmosphere annually) is available at earth's surface to do work.
j) 49% - Does not reach earth surface.
4% - Reflected back to space by earth surface.
26% - Scattered or reflected to space by clouds and atmospheric particles.
19% - Absorbed by atmospheric gases, particles and clouds.
k) Average duration of light in equatorial region = 12 hours per day.
l) Region where 24 hours light in summer and 24 hours darkness in winter – Tundra.
m) Division of ocean water and large lakes on the basis of penetration of light.
i. Euphotic zone – Upto depth of 80m from surface.
– Aquatic vegetation, phytoplanktons and animals abundant.
ii. Dysphotic zone – 80m to 200m deep.
– Limited photosynthesis.
– Light rays absorbed at different depths→Red – First 4 meters.
Orange – First 20 meters.
Yellow – First 50 meters

Green and violet – First 100 meters.
Blue – Beyond 100 meters.

iii. Aphotic zone – Deeper than 200 meters. No photosynthetic plant.

Biological effects of light.

a) Pigmentation – More light → more pigmentation.
  i) Tropical region → Dark colour skin.
  ii) Temperate region → Light colour skin.

b) Movement:
  i) Taxis – Movement of entire organism.
  ii) Phototaxis – Oriented locomotor movement of an animal in response to light.
   - Positive phototaxis – movement towards light source e.g. *Euglena*.
   - Negative phototaxis – movement away from light source e.g. Earthworms,planarians, cockroaches, etc.
  iii) Photokinesis – Non directional movement.
   – More light, more speed or rate.
   e.g. Larvae of mussel crab *Pinnotheres maculatus* moves faster.

c) Vision.

d) Behavior – i) Diurnal animals – Active during day time.
  ii) Nocturnal animals – Active during night time. e.g. owl, bat.

e) Metabolism – Increases with light.

f) Ultraviolet rays -
  i) Wave length = <380 nm.
  ii) Wave length of UV – C = 100nm to 280nm (Lethal).
  iii) Wave length of UV - B = 280nm to 320 nm (harmful to organisms)
  iv) Wave length of UV - A = 320 nm to 380nm.
  v) Prolonged exposure → Causes skin cancer in man.
  vi) Convert sterols of skin into vitamin D.

g) Biological Rhythm – Behavioural activities of living organisms occurring at regular intervals at the same time.
  i) Circadian rhythm – Bio-rhythm with a periodicity of about 24 hours.
   e.g. i) Emergence of fruit flies from pupae at dawn &
   ii) Return of birds to nests at dusk.
  ii) Circalunar rhythm (lunar periodicity) – Correlation of some activities of organisms and phases of moon.
   e.g. Reproductive cycle of few polychaetes e.g. *Eunice viridis* (palolo worm). Swarming (movement in pelagic water) occurs during last quarter of lunar cycle to release eggs and sperms.
  iii) Biological clocks – Innate, endogenous mechanism controlling biorhythms. Light is an entrainer that sets or resets the biological clocks.

h) Photoperiodism –
  i) Photoperiod – Duration of an organism's daily exposure to light.
  ii) Photoperiodism – Response of organism to length of photoperiod. e.g.
   - Migratory behavior in birds,
   - Development of gonads &
   - Deposition of body fat.

iii) Critical photoperiod – Specific length of photoperiod (12.5 hours) e.g. Size of testis gets affected by photoperiod in hamsters.Longer photoperiod $\rightarrow$ large testes.
iv) Circannual rhythms – Responses occurring in late summer or autumn due to change in length of photoperiod.
v) Short day animals – An action (mainly reproduction) occurs when photoperiod falls below critical photoperiod (during spring).
vi) Long day animals – An action will not occur until the photoperiod had passed the length of critical photoperiod (during late summer or autumn).
vii) Diapause – A period during which growth and development is suspended due to adverse environmental conditions e.g. In insects.

i) Bioluminescence or Biological light or Cold light
   i) Heat can not be produced or generated due to absence of infra red rays.
   ii) Light is emitted due to presence of protein luciferin and enzyme luciferase.
   iii) Luciferin is acquired through food chain or synthesized with in organism it self. Types of luciferin molecules = 6.
   iv) All the reactants together form a unit called photoproteins that is triggered to produce light by Ca^{++} ions

   $$\text{Luciferin} + O_2 + \text{Salt} + \text{ATP} \xrightarrow{Luciferase} \text{Oxyluciferin} + H_2O + \text{ADP} + \text{light}$$

   e.g. Jelly fishes, cternophores, *Chaetopterus*, squids, *Pyrosoma*, deep sea fishes, some protozoans. etc.

B) Temperature:
   a) Measure of heat intensity
   b) Main source $\rightarrow$ Sun.
   c) Inland areas - Show extreme variations in temperature from day to night and from season to season.
   d) Eurythermal animals– Can tolerate wide fluctuations in temp. e.g.Lizards,birds, mammals
   e) Stenothermal animals – Can tolerate only small variations in temperature. e.g. Coral animals, fishes etc.
   f) Optimum temperature – Temperature at which organism's life activities are at maximum level.
   g) Minimum effective temperature – Lowest temperature at which organisms can live indefinitely. Below this temperature organism goes into **chill coma.**
   h) Minimum survival temperature – Lowest temperature at which survival is possible.
   i) Maximum effective temperature – Highest temperature at which an organism can live indefinitely. Above this temperature organism goes into **heat coma.**
   j) Maximum survival temperature – Highest temperature at which survival is possible.

Thermal stratification –
   a) Formation of layers of water in fresh water lakes due to temperature variations.

b) It occurs in temperate lakes (not in tropical).
c) Summer stratification –
   i) Epilimnion – 21 to 25^o C, warm, O_2 rich upper layer.
   ii) Thermocline or metalimnion – Rapid decrease in temperature
   (decrease of 1^o C per meter of depth).
   iii) Hypolimnion – Cold, O_2 deficient lowest layer (if thermocline develops).
d) Fall over turn – During autumn or fall (late August to November) → surface temperature decreases → density of water increases →density is highest at 4^{o}C → water becomes heavy → sinks at bottom → warmer and light water rises to top → water circulates.
e) Winter stratification or stagnation – Surface water (4^{o}C) →freezes to ice (0^{o}C) where as water below remains at 4^{o}C.Organisms below do not face hypoxia due to decrease in bacterial decomposition and respiratory activity of aquatic organisms.
f) Spring over turn – During spring, temperature of surface water increase upto 4^{o}C → water melts and becomes heavy → sinks→ water circulates.
g) Overturn helps in periodic replenishment of nutrients and O_2 in upper and lower waters.

Biological effects of temperature:

a) Body temperature
   i) Warm blooded or homoeothermic endotherms –
      - Animal who can maintain their body temperature at a constant level, irrespective of atmospheric temeperature.
      - They depend on internal heat (generated within body) to regulate heat lost.e.g. Birds and mammals.
   ii) Cold blooded or poikilothermic ectotherms
      - Animals who can not maintain their body temperature at a constant level.
      - They depend on external heat (no internal mechanism).
        e.g. Fishes, amphibians, reptiles.
      - In extremes of temperatures, animals undergo hibernation (winter sleep) and aestivation (summer sleep).
   iii) Regional ectotherms – Ectotherms living in a constant environment. They maintain their optimum temperature by adapting to heat exchanges. e.g. Deep sea and polar regions.
   iv) Heterotherms – Animals that maintain their body temperature in some organs or for short periods. e.g. Sharks maintain body temperature in muscles.
b) Thermal migration – To escape from extremes of temperature – e.g.
   i) Desert animals → move to shades in noon.
   ii) Hippopotamus, crocodiles, amphibians → move between land and water.

c) Metabolism –
   i) Increase in temperature to certain limit (optimum temperature), increases rate of metabolism (in poikilotherms).
   ii) Bio-kinetic zone – 4^o C to 45^{o}C.

iii) Van't Hoff's rule – Rate of biochemical reaction doubles with every 10^oC rise in temperature, upto a certain level.
iv) Effect of temperature on rate of reaction is expressed as temperature co-efficient or Q_{10}.
v) Value of Q_{10} for an enzyme controlled reaction = approximately 2.
vi) $Q_{10} = \frac{\text{Rate of reaction at } x^oC}{\text{Rate of reaction at } (x-10)^oC}$.

d) Effect of temperature on sex ratio-
   i) In rat flea *Xenopsylla cheiopis* and in *Agama* (lizard), male population increases with increased temperature.
   ii) In turtles, female population increases with increased temperature. Bipotential gonads are masculanised in the absence of a temperature- trigger, whereas female producing temperatures cause the enzyme aromatase to act locally on gonads to produce estrogen and activate the development of ovaries.

e) Cyclomorphosis – Modifications in body form in relation to seasonal changes in temperature.
   i) In winter – Round head (water cool and dense, it can easily float).
   ii) In spring – Helmet like projection.
   iii) In summer – Maximum helmet like projection (water warm and less dense, hood increases surface area for buoyancy).

f) Other effects of temperature:
   i) Bergmann's rule – Temperature effects body size.
   e.g. Large body size of homeotherms in cold regions (polar bears and whales) to reduce heat loss (more volume, less surface area).
   ii) Allen's rule – Extremities of homeotherms (ear, tail, leg, snout) of colder regions are shorter to prevent heat loss.
   iii) Jordan's rule – Temperature influences early segmentation during development.
   e.g. In Cod fish → at 4^oC to 8^oC→ 56 vertebrae at 10^oC to 11^oC → 54 vertebrae
   iv) Glogger's rule – Temperature affects pigmentation.

C) Water –

Properties of water

a) Hydrosphere – 71% of earth surface.
b) Percentage of water in living organism's body = 70 – 90%.
c) Hydrological cycle – Circulation of water between atmosphere and earth's surface. (evaporation and condensation)
d) Universal solvent
e) Specific heat – Amount of heat required to raise the temperature of 1 gm of water by 1^oC. water has high specific heat (great capacity for absorbing heat with minimal change in temperature).
f) Latent heat of fusion – Quantity of heat required to convert 1 gm of ice at 0^oC into water at 0^oC. (80 calories).
g) Latent heat of vapourization – Quantity of heat required to convert 1gm of water at 100^oC to steam at 100^o C (540calories).

h) Surface tension – Higher than other liquids (except Hg). Due to this animals move or skate on water surface. e.g. Water bugs.
i) Pressure - For every 10meter increase in depth, pressure increases by 1 atmosphere. e.g. Deep sea organisms.
j) Density – Highest at 4^{o} C (Anomalous property).

Water problems and their management in aquatic animals

a) Adaptations – Spindle shaped body, fins, and paddles.
b) Homeostasis - Maintain constant internal environment by osmoregulation.

Fresh water habitat.

a) More water potential (more water or low concentration).
b) Water enters in body by **Endosmosis.**
c) Well developed **glomerular kidney** (to remove dilute urine).
d) **Chloride cells** in gills absorb lost salts.
e) **Contractile vacuoles** develop (e.g. in *Amoeba*)
f) **Aestivation** (summer sleep) – African lung fish, *Protopterus* burrows deep in mud and forms a gelatinous cocoon around itself.
g) Protists secrete protective cyst in summer.
h) Sponges form gemmules (asexual reproductive bodies) in summer.

Marine water habitat:

a) Water potential less.
b) Loses water by **exosmosis.**
c) **Aglomerular kidney** or few nephrons without glomeruli.
d) Fishes drink more water.
e) Chloride cells in gills remove excess salts.
f) In sea gulls and penguins → catch fish → extra water with salt enter salt secreting glands → ducts → nasal cavity → salt water drips out through nostrils.
g) In giant turtle (a marine reptile), salt glands open through ducts near the eyes.
h) **Uraemia** – Some marine cartilaginous fishes store urea and TMO (Tri methyl amine oxide) in blood to maintain the body fluid concentration isotonic to marine environment.

Estuarine habitat:

a) Estuary – Region where river opens into sea.
b) Salinity – Wide range of variation in different seasons.
c) Euryhaline animals – Brakish water animals can tolerate wide fluctuations in salinity.
d) Anadromous migration – Migration from sea water to fresh water for breeding in fishes e.g. Hilsa, Salmon.
e) Catadromous migration – Migration from fresh water to sea water for breeding in fishes e.g. *Anguilla bengalensis*.
f) Glomerular kidneys.
g) Chloride cells help in absorption or excretion of salts.
h) Salmon maintains its cytoplasm isotonic to fresh water of river by
i) stops taking food and ii) drinking more water.

Water problems and their management in terrestrial animals –

Water conservation techniques:

a) Insects – Chitinuous exoskeleton.
b) Reptiles birds and mammals – Uric acid as excretory product.
c) Spiders (arachnids) – Guanine as excretory product.
d) Mammals – Hypertonic urine (Henle's loop).
e) Wall lizards – Utilize food water only.
f) Thorny devil, *Molloch horridus* (desert lizard) –
   i) Hygroscopic system of grooves in skin.
   ii) Water enters by capillary action (gulping oral mechanism.
   iii) Can drink from dew falling on their back.
   iv) Gain a gram of water in a rain storm.
g) *Neotoma* (wood rats of desert) – Use water from its food cacti.
h) *Dipodomys spectabilis* (kangaroo rats) – Depends on metabolic water (do not drink water)
i) Fossorial animals – Come out of burrow during night only.
j) Earthworms – Live in moist soil.
k) Amphibians – Lay eggs in water.
l) Cleidoic eggs – Vertebrates like reptiles and birds lay **shelled** eggs with a fluid filled **amnion** around embryo.
m) Camels : i) Sweat at 41^{o}C and above
   ii) Can survive even after losing body water → 40% of its bodyweight.
   iii) Body heat is lost easily through skin due to absence of subcutaneous fat (present only in hump).
   iv) Temperature fluctuations during day and night and efficiency in sweating helps in preservation of about 5 liters of water per day.
   v) Oval RBCs facilitate their flow in dehydrated state.

Biotic Factors and Trophic levels

I) Composition of Biotic Community

A) Producers – First trophic level
– Trap radiant energy
– Green plants and phytoplanktons
– Fe and S bacteria (chemoautotrophs)

B) Consumers or macroconsumers –

a) Primary consumers (or herbivores) – Second trophic level
   i. On land – cow, deer, rabbit, grasshopper, snails.
   ii. In water – protists, crustaceans, molluscs, zooplanktons.
b) Secondary consumers (or primary carnivore) – Third trophic level.
   i. On land – frogs, dogs, foxes, wolves.
   ii. In water – fishes.
c) Tertiary consumers (or secondary carnivore) or climax consumer
   i. On land – hawks, vulture, lion, tiger.
   ii. In water – large predatory fishes

C) Decomposers or microconsumers recycle the dead organisms and waste materials & release energy into ecosystem. e.g. Fungi and Bacteria.
   i. Saprotrophs – Absorb substances through general body surface from dead bodies.
   ii. Detritivores – Ingest detritus as food.

iii. Mineralisers – Mineralise humus.

Characters of a biotic community

1. Species composition – Kind of organisms present in biotic community.
2. Dominant species – A few species that influence the other species in terms of number and biomass. e.g. Pine trees in taiga and grass in grasslands community.
3. Keytone species – Species which greatly influence biotic community relative to their abundance in biomass or number. e.g. Fig trees in tropical forests (produce large amount of fruits).
4. Link species – Species who absorb nutrients from soil and organic residue e.g.Mycorhizal species.
5. Critical link species – Species useful in pollination and dispersal of organisms e.g. Insects.
6. Ecotone – Transition zone between two communities e.g. Zone betweenforest and grass land.
7. Edge effect – Increase in number and diversity of organisms.
8. Edge species – Species in ecotone.

Interactions:

1. Competitive exclusion – One species excludes its competitor. e.g. *Lemna gibba* dominates *Spirodela pylorhiza*.
2. Allelopathy – Chemical inhibition of one species by other. e.g. In Pine forest, needles shed and release acids in soil that inhibit grass and other plants from growing.
3. Symbiosis (mutualism, commensalism, amensalism, parasitism). Amensalism – one is harmed, other is unaffected.
4. Predation –
   a) One organism (bigger) kills other (smaller) for food.
   b) It is a conduit for transfer of energy in a food chain.
   c) It limits the population size of prey.
5. Important adaptations in prey to avoid predation –
   a) Camouflage (blending colouration).
   b) Venomous nature.
   c) Spiniscence (spines over body).
   d) Warning colouration.
   e) Mimicry (two species resembling each other).
6. Batesian mimicry – Type of defenceless organism (mimic), mimicking other organism (model) having a defence e.g. Viceroy butterfly (without poison).
7. Mullerian mimicry – Mimics share the same defence mechanism as model.

Ecological succession – Process of occurrence of gradual, orderly and predictable changes in composition of communities towards a climax type.

1. Primary succession – The succession which begins on an uninhabited area to establish a climax community.
2. Secondary succession – It begins in an area from which a community was removed to establish a climax community.

3. Autotrophic succession – An inorganic environment predominated by autotrophs.
4. Heterotrophic succession – Polluted areas with more decomposed matter and dominated by heterotrophs.
5. Pioneer community – The first communities established either in primary or secondary succession.
6. Each seral stage (of changed habitats) has its specific seral community.
7. Climax community is established after stabilization of environment.
8. Successions are of 3 types (on the basis of types of habitat and amount of moisture)
   a) Xerosere –Succession that starts on barren rocks or in places with extreme water deficiency.
   b) Hydrosere – Succession starting in habitat rich in water.
   c) Mesosere – Succession starting in habitat with moderate water.

Food chains - Chains of organisms through which energy is transferred (or sequential interdependence of one trophic level over other)

Producers (I trophic level)	→	Primary consumers (Herbivores) (II trophic level)	→	Secondary consumers or Primary Carnivore (III trophic level)	→	Secondary & Tertiary carnivores (IV and V trophic level) (Predators)
						↓
				Decomposers (saprotrophs, detritivores and mineralizers)	←	Top or Climax Carnivore

1) **Grazing food chain or Predator food chain**: - Linear, upto 4 or 5 trophic levels.
   a) In terrestrial ecosystem –
      i. Grass → deer → tiger.
      ii. Grass → grasshopper → frog → snake → hawk.
      iii. Rosebush sap → aphids → spiders → small birds → hawk.
   b) In an aquatic ecosystem –
      Phytoplankton → zooplankton →small fish → squid → seal.
2) **Parasitic food chain**:
   Hosts (larger) → parasites (smaller)
3) **Detritus food chain**:
   a) $\boxed{\text{Dead animals of grazing food chain, waste materials of living organisms}}$ → flies & maggots →frogs→snake

      ↑
      Detritus
   b) Leaf litter → earthworms → birds → hawk.

Food web:
1) Cross linking of different trophic levels of different food chains form a mesh or web.
2) It maintains the stability of ecosystem.
3) More number of alternative pathway →more stable biotic community.
4) Omnivores – Animals feeding on organisms of different trophic levels.
5) Iota link – A direct linking between prey and predator without any branching.
6) Lambda link – A branching link in which a predator feeding on more than one type of prey organisms.
7) Gamma link – A branching link in which one prey organism is predated by more than one type of predator.

Ecological pyramids –
1) Represents trophic structure (feeding relationship) and trophic function (efficiency of energy transfer through biotic factors).
2) Graphical representation designed as triangle to show the numbers or biomass or energy at each trophic level.
   A) Pyramid of numbers –
      a) Aquatic or lake ecosystem – upright triangle.
      b) Parasitic food chain – inverted.
   B) Pyramid of biomass (dry weight of organism – grams / m^2 or grams / m^3) → upright.
      In pond – may be inverted (biomass of phytoplanktons → less)
   C) Pyramid of energy – always upright.

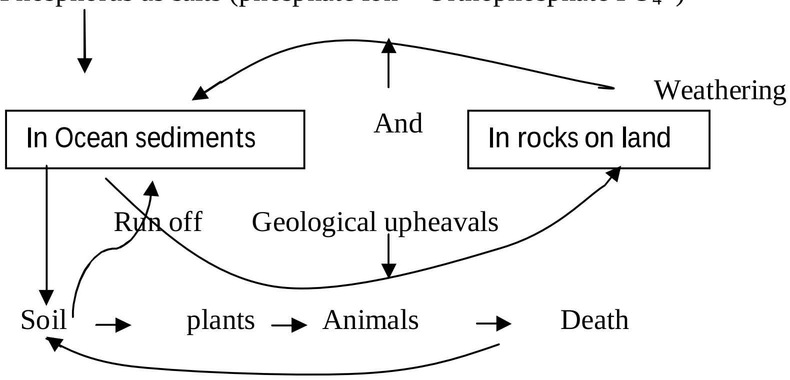
Functional aspects of an ecosystem:
1. Main processes related to the field of ecosystem ecology are
   a) energy transformations and b) biogeochemical cycling.
2. Energy that enters ecosystem →Light energy.
3. Photosynthesis – A process in which light energy is converted to chemical or potential energy.
4. Potential energy is converted to → Kinetic energy.
5. If no continous entry of solar energy → Biological system gets closed.
6. Earth as an **open** system → Regarding the energy flow. If it is lost, it can not be recycled.
7. Earth as a **closed** system (except meteorite) → Regarding the flow of elements. These are neither destroyed or lost nor replenished.
8. Nutrients – Elements whose non-supply tends to limit biological activity.

Biogeochemical cycle:
1. It is a pathway by which a chemical element or molecule moves through both biotic & abiotic components.
2. Closed system.
3. Reservoir pools (abiotic factors) – The place where chemicals are held for long periods of time at one place.
4. Exchange pools (biotic factors) – The place where chemicals are held for short periods.

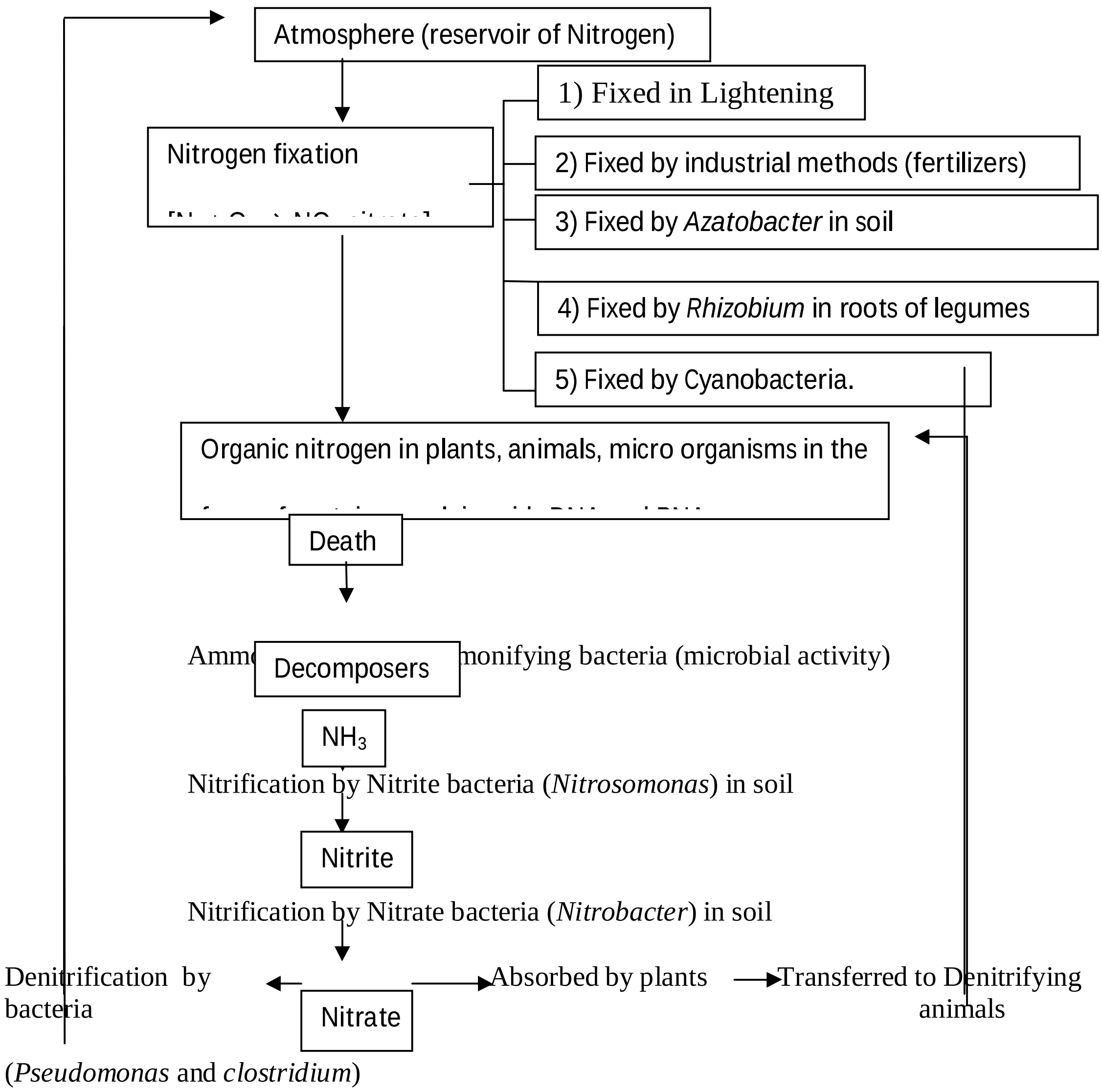
5. Residence time - The period of time that a chemical is held in one place.
6. Gaseous cycle – Nitrogen and Carbon cycle. (Reservoir is atmosphere).
7. Sedimentary cycles – Sulphur and Phosphorus cycle. (Reservoirs are sedimentary rocks).

Phosphorus cycle:

Phosphorus as salts (phosphate ion – Orthophosphate PO_4^{3-})



Nitrogen cycle:



Energy Flow:

1. Energetics – Study of law of energy and its transformation.
2. Joule – Standard international unit of energy.
3. Calorie – Convention unit of energy, still in use.
4. Energy flow in an ecosystem is **unidirectional.** (one trophic level to next).
5. Standing crop – Weight or quantity of organisms in an area at a given moment.
6. Productivity – Total amount of organic material produced by living organisms of a particular area within a set period of time.
7. Flow of energy occurs as open system.
8. Primary productivity - Rate at which biomass is produced by organisms which convert inorganic substrates into complex organic substrates through a) photosynthesis & b) chemosynthesis (bacteria convert chemical energy to biomass).

9. Gross Primary Productivity (GPP) → Total Primary Productivity.
10. Net Primary Productivity (NPP) → Energy stored in plant tissues.
11. Net Primary Production = Gross Primary Production – Energy utilized for Respiration.

$$\boxed{NPP = GPP - R}$$

12. Secondary Primary Productivity – The rate at which consumers of an ecosystem convert the chemical energy of their ingested food material into their own body substances (biomass).
13. Gross Secondary Production = Total plant material ingested by herbivores – Materials lost as feaces.
14. Net Secondary Production → Energy stored in the tissues of consumers for growth and reproduction (a part is lost in respiration).
15. Proportion of energy lost in first transfer of energy from solar energy to chemical energy in producer is high (99%).
16. Average trophic Efficiency (Efficiency of transfer of energy from one trophic level to higher trophic level) = 10% (**10% rule or Lindeman's trophic efficiency rule)**
17. Exploitation efficiency = $\dfrac{\text{food ingested}}{\text{total food available for ingestion}} \times 100$
18. Assimilation efficiency = $\dfrac{\text{food digested}}{\text{total food digested}} \times 100$
19. Assimilation efficiency of herbivores is less than that of carnivores (herbivores make less efficient use of their food → plants contain more cellulose and some other substances that are indigestible and therefore unavailable as source of energy).
20. Assimilated energy = Exploitation efficiency × Assimilation efficiency.

Lake Ecosystem:

1. Limnology – Study of fresh water ecosystem.
2. Lentic ecosystem – Static water ecosystem. e.g. ponds, lakes, tanks.
3. Lotic ecosystem – Flowing or running water ecosystem e.g. rivers, streams, canals.
4. Oligotrophic lakes – Poor in nutrients.
5. Eutrophic lakes – Rich in nutrients and O_2.
6. Dystrophic lakes – Rich in nutrients, poor in O_2.
7. Lakes are different from ponds by
   a) their greater depths and
   b) presence of water throughout the year.
8. Number of zones in deep lakes = three.
   A) **Littoral zone** :
      a) Shallow water zone near the shore.
      b) Efficient light penetration, abundant vegetation and consumers.
      c) High O_2, warmer water.
      d) The plant that forms inner border is *Chara*.

III. Produc

- **Rooted plants**
  - **Emergent vegetation or Amphibious plants** - (partly submerged, partly exposed) e.g. ***Typha* (Cattails*)*, S*cirpus* (bulrushes*)*, *Sagittaria***
  - **Floating vegetation**: (Broad leaves provide space for aquatic animals to rest and lav
    - Free floating e.g. ***Pistia, Wolffia, Lemna* (duckweed*), Azolla, Eichhornia.***
    - Rooted and floating: e.g.
  - **Sub merged vegetation**: (away from bank, in
    - Rooted to soil e.g. ***Vallisneria, Chara* (musk**
    - Free submerged e.g. C***eratophyllum*(coontails*),***
- **Phytoplanktons** (important producers) – Chlorophyll bearing, floating micro organisms. e.g.-
  - ii. Diatoms **–*Coscinodiscus, Nitschia***
  - iii. Green algae **– *Volvox, Spirogyra***

IV. Consu

- **Zooplankton: -** Microscopic, floating
  e.g. protozoans, rotifers, crustaceans (copepods- *Cyclops*),
- **Nekton:-** swimming
  e.g. fishes, amphibians, terrapins, water snakes, insects like ***Ranatra*** (water scorpion), ***Notonecta*** (back swimmer), diving
- **Neuston:-** Air water interface
  - **Epineuston** or **supra neuston** (above water)
    e.g. ***Gerris*** (water striders), beetles
  - **Hyponeuston** or **infra neuston** (below water).
- **Periphyton** – Clinging to aquatic plants.
  e.g. water snails, nymphs of insects, bryozoans,
- **Benthos**: Bottom of sand
  e.g. chrionomid larvae, clams, red annelids,some

B) **LIMNETIC ZONE**

a) Open water zone upto depth of effective light penetration or compensation level (rate of photosynthesis = rate of respiration).

b) Absent in shallow ponds.

i) **Producers –** e.g. Euglenoids, cyanobacteria, dinoflagellates and green algae.Phytoplanktonic organisms.

ii) ***Consumers –***

- **Zoo planktons -** e.g. copepods.
- **Nekton –** e.g. fishes, frogs, snakes
- **Neuston** sometimes.

C) **PROFUNDAL ZONE:**

a) Bottom, deep water zone.

b) No light, no plants

c) Low O_2, thick layer of mud and sand.

d) Water contains nekton.

e) Bottom contains benthos e.g. Chironomid larvae (blood worms), red annelids and some molluscs (clams).
f) Bacteria – large numbers → decompose dead animals →release nutrients to biotic community of limnetic and littoral zone. (recycling of nutrients).
g) ***Chaoborus*** (Phantom larva) – as plankton.
   i. During night goes to limnetic zone.
   ii. During day live as benthos.

POPULATION ECOLOGY OR AUTECOLOGY – (sub field of ecology).

1. It is a science that deals with dynamics of species populations and their interaction with environment.
2. Malthasian growth model/simple exponential growth model – Increasing competition for food, shelter etc., due to exponential growth of population.
3. Population – A group of organisms belonging to same species living in an area.
4. Population dynamics – Study of changes in the size of population.
5. **Population characteristics –**
   A) **Natality –** Number of young individuals produced in a unit time.
      a) Absolute natality rate – Natality rate in entire population.
      b) Specific natality rate – Natality rate per individual in a population.
      c) Potential natality rate – Maximum natality rate in a population under unlimited environmental conditions.
      d) Ecological natality rate – Natality rate under given limited ecological conditions.
      e) Ecological natality rate is always less than the potential natality rate.
      f) Natality rate in human beings – Number of births/year/thousand in a population.

   B) **Mortality –** Death of individual in a population.
      a) Potential mortality rate – Minimum number of deaths under unlimited conditions.
      b) Ecological mortality rate – Death of individuals under given ecological conditions.
      c) Potential mortality rate is always less than ecological mortality rate.
      d) Mortality in human beings is No. of deaths /year/thousand.
      e) Relative rates of natality and mortality regulate the **size** of a population.

   C) **Population dispersal –** Movement of individual into and out of a population.
      a) Emigration – Outward movement of individuals from a population to another area.
      b) Immigration – Inward movement of individuals into population from neighbouring areas.
      c) Migration - Outward movement from an area and return movement to that area.
      d) Migrations regulate the size of population.

   D) **Population density –** Number of individuals per unit area or volume.

$$\textbf{Density (D)} = \frac{\textbf{Number of individuals (N)}}{\textbf{Area}}$$

Factors influencing density of population - Natality, mortality, emigration, immigration, environmental factors (seasons, climatic conditions, availability of food).

E) **Population Growth** – Biological feature exhibited by populations of all species. Growth rate (r) = Specific natality rate (b) – Specific mortality rate (d).
   a) Growth is determined i) by reproductive potential of organisms and ii) by environmental resistance.
   b) Biotic potential – Maximum reproductive potential under unlimited environmental resources.
   c) Environmental resistance – Sum total of limiting factors (biotic and aboitic) which act together to limit the population size.

F) **Growth curves** - Graphic representation of growth and decline in size of population over a unit period of time, under given environmental conditions.
   a) S-Shaped or Sigmoid growth curve or Logistic curve – Common growth pattern exhibited by many micro organisms, plants and animals.
      i) Lag phase or positive acceleration phase – Initial slow growth of a population in a new environment.
      ii) Logarithmic phase – Rapid growth phase of population during which births greatly exceed death rate.
      iii) Negative acceleration phase – Decrease in population due the declining birthrate or rising death rate.
      iv) Zero population growth phase –
         - Natality rate equals the mortality rate and population stabilises.
         - Environmental resistance increases.
         - It represents the maximum carrying capacity of the given environment for concerned organisms.
      v) S-shaped growth curve is explained with the example of yeast cells.
      vi) Carrying capacity – Maximum stable population that a particular environment can support over a long period of time.
      vii) Density dependent – Growth rate in sigmoid growth pattern depends on numbers present in population
   b) J-shaped growth curve or Exponential growth curve – e.g. Algal blooms and aphids (plant sap sucking insect).
      i) Lag phase – Initial establishment phase.
      ii) Population continues to grow exponentially and reach the peak level.
      iii) Crash – Sudden decrease in the population from peak level because of certain factors (seasonal change, end of breeding season etc).

iv) Density independent – Growth rate in J-shaped growth pattern is not dependent on population density until the final crash.

G) **Age distribution –**

a) Number of age groups in a population – **3**.
   i) Pre reproductive age groups (young)
   ii) Reproductive age groups (middle aged)
   iii) Post reproductive age groups (old).
b) Age pyramid – Diagrammatic representation of size of a population basing on distribution of age groups (pre-reproductive age group at bottom & post- reproductive age group at the top)
c) Shape of pyramid – It indicates the status of a population.
   i) Triangular shape – Growing population (pre-reproductive age group more in numbers).
   ii) Bell shape – Stable population, (all age groups in equal numbers)
   iii) Urn shape – Declining population (post-reproductive age groups more in number).

H) **Population regulation**-

a) Density independent factors or Extrinsic factors – Factors that affect the birth rate or mortality rate of a population in ways that are independent of population density. e.g. temperature, food, space, shelter.
b) Density dependent factor or Intrinsic factors – Factors that affect birth rate or mortality rate of a population in ways that are varying with population density. e.g. competition, predation, migration, disease, territorial behaviour.

BIODIVERSITY: Conservation of wild life

1. Biodiversity –
   a) Variety of all living things.
   b) Diversity of life
   c) Variations of life at all levels of biological organization within a species, among species and comparative diversity among ecosystems.
   d) According to ecologists, it is totality of genes, species and ecosystem of a region.
2. Total number of species estimated → 7 to 20 million.
3. Total number of species described scientifically → 1.75 million.
4. Current extinction rates are 100-1000 times higher than pre human period extinction rates.
5. Vast majority of species are concentrated in tropical and subtropical regions.
6. Genetic diversity –
   a) Diversity of genes (number of genes of a specific trait) within a species.
   b) Increases with environmental variability.
   c) Advantageous for survival.
   d) Genetic variations occur due to genetic recombinations, gene or chromosomal mutations.
   e) Estimated number of genes distributed across the world's fauna and flora = 10^{10}

7. Species diversity –
   a) Diversity among species in an ecosystem or variety of species within a region. e.g – Biodiversity hot spots.
   b) Species richness-
      i. Simplest measure of biodiversity.
      ii. Number of species per unit area.
      iii. More the number of species in an area more is the richness.
      iv. Richness increases from high altitudes to low altitudes.
      v. Peak of richness is between 20^0 N and 30^0 N (not at equator).
      vi. Level of richness increases rapidly from Northern region to equator and decreases slowly from equator to southern region.
      vii. Higher species diversity at lower latitudes.
      viii. Greater is the richness, greater is the diversity.
      ix. Species evenness – Relative abundance of different species making up the richness of the area.
      x. Species diversity depends both on richness and evenness.
8. Ecosystem diversity -
   a) Variety of ecosystems on earth.
   b) Alpha diversity – Diversity within a particular area, community or ecosystem. It is measured by counting number of taxa (usually species) within the ecosystem.
   c) Beta diversity – Species diversity between two ecosystems. It involves comparing the number of taxa that are unique to each of ecosystems.
   d) Sorensen's similarity index $\beta = \dfrac{2C}{S_1 + S_2}$

      Where S_1 = Total No. of species in first community.
      S_2 = Total No. of species in second community.
      C = No. of species common to both communities.
   e) Gamma diversity – Measure of overall diversity for different ecosystems within a region.
9. Biotope – An area that is uniform in environmental conditions and in its distribution of animal and plant life.
10. Eco-regions – An area constituting a natural ecological community with characteristic flora, fauna and environmental conditions and bounded by natural borders.
11. Eco-zone or Biogeographic realm –
    a) Largest scale biogeographic division of earth's surface based on historic and evolutionary distribution patterns of plants and animals.
    b) It represents large areas of earth's surface where plants and animals developed in relative isolation over long periods of time because of geological barriers (oceans, deserts, mountains, valleys etc.).
12. Endemic species – Unique species of a particular area.
13. Sites of active speciation – Areas rich in endemic species.

14. Biodiversity hot spot – A biogeographic region that is both a significant reservoir of biodiversity and is threatened with destruction.
15. Conservation International (CI) - Organization that is focused on biodiversity hot spot. It has identified 34 biodiversity hot spots by 2006.
16. Biodiversity hot spots related to India – Himalaya's, Indo - Burma and Western Ghats & Sri Lanka.
17. World wide fund for nature (WWF-formerly World Wild Life Fund) focussed over 200 ecoregions for conservation of biodiversity.

Role of Biodiversity:-

1. Ecological role –
   a) Each species has a specific kind of role in the ecosystems.
   b) They help in capturing and storing energy, produce and decompose organic material, help to recycle water and nutrients, fix atmospheric gases (or help to regulate climate).
2. Economic role –
   a) Food - i) Number of animals used as food →**12.**
      ii) Number of crops cultivated for food supply →**15**.
      iii) Wheat, corn and rice supply 2/3rd of total food.
   b) Medication –
      i) Bark of Cinchona tree → quinine →treat malaria.
      ii) Fox glove plant →digitalin →treat chronic heart trouble.
      iv) Poppy plant → morphine → pain relief.
      v) Vinca plant→ vinblistin, vincristin → anti cancer drugs (70% comes from plants of tropical rain forests).
      vi) Sarpagandha plant → anti hypertensive drugs.
   c) Industry
      i) Plants supply – oils, lubricants, perfumes, dyes, camphor, cork,resins, paper waxes, rubber, latexes and poisons.
      ii) Animals supply – honey, lac, wool, silk, fur, leather, lubricants, waxes, mode of transport.
      iii) Pyrethrin – a biodegradable pesticide extracted from C*hrysanthemum*
      vii) Biopesticide – a bacterium *Bacillus thuringiensis.*
   d) Eco-tourism and recreation – parks, forests, outdoor recreational activities.
3. Ethical role – It is morally wrong to voluntarily cause extinction.
4. Scientific role –Each species gives some clue to scientists regarding evolution.
5. Environmental role – Biodiversity maintains homeostasis of ecosystem.

THREATS TO BIODIVERSITY

1. Habitat degradation and its loss – deforestation.
2. Invasion of non-native species-
   a) Exotic species, Nile perch reduced endemic species of great African lakes Victoria, Malawi and Tanganyika.

b) Lantana bushes, Eupatorium shrub, *Parthenium*, Hyacinth (all exotic) introduced to India are causing great damages to endemic plants.

3. Species Interdependence e.g. *Clavaria major*, an exclusive tree of Mauritius became endangered, due to extinction of Dodo bird (*Ruphus cuculeatus*) in 17th century (seeds of tree germinate, when pass through the abrasive gut of bird).
4. Erosion of barriers –
   a) Natural barriers protect endemic species form invasion of other species.
   b) Super species – Highly fecund, ultracompetitive, generalist species responsible for the loss of endemic species in an area.
5. Pollution – Amplification of pollutants in different trophic levels of a food chain is called **biomagnification.**
6. Over exploitation of resourses by logging, hunting, poaching, fishing.
7. Change in global environment.

CONSERVATION OF BIODIVERSITY

I. **In-situ conservation/ on-site conservation-**

1. Process of protecting an endangered species in its natural habitat (a network of protected areas).
2. It maintains recovering populations in the surrounding, where they have developed their distinctive characters.

A. **National parks –** Natural habitats (forests) of certain endangered species (no biotic interference allowed).

Earliest National parks – a) Yellow stone park in USA.
b) Royal National park in Australia.

B. **Sanctuaries –**

a) Areas where specific endangered faunal species are well protected (limited biotic interference is permitted).
b) Areas where private ownership of land is allowed and boundaries are not subscribed.

C. **Biosphere reserves –**

a) Area meant for conservation of biosphere reserves and for improvement of relationship between man and environment.
b) Protected area for whole ecosystem.
c) Protected site for long term scientific research and education.
d) Functions –
   i) Conservation functions - Conservation of landscapes, ecosystems, species and genetic variation.
   ii) Development function - To foster economic and human development.
   iii) Logistic function - To support research, education, monitoring information, exchange etc.
   - Core zone → Undisturbed and legally protected area of biosphere reserve.
   - Buffer zone →Surrounds the core zone and accommodates resource management strategies, research and education.

- Transition zone → Outermost, an area of active co- operation between reserve management and local people where sustainable resource management practices are promoted and developed.

D. **Sacred forests and lakes –** Undisturbed areas protected by local communities.

II. **Ex- situ conservation / off-site conservation –** Conservation of genetic recources of species away from their area of origin or development.

A. **Off-site collection** - Collection of wild and domesticated organisms in botanical gardens and zoos.

B. **Gene Banks –** 4 types

a. Seed gene banks
   i) Orthodox seed banks - seeds that can tolerate moisture upto 3 %, anaerobic condition and low temperature for prolonged periods are stored e.g. cereals and legumes.
   ii) Recalcitrant seed banks - seeds that are hard to preserve (recalcitrants - cannot tolerate low moisture and temperature) are stored. e.g.coconut, cocoa seeds, tea, jack fruit.

b. Field gene banks / orchards – maintain recalcitrant plants.

c. In-vitro preservation –
   i) Development of callus, embryoids, pollen grains, shoot tips for plants without visible seeds by using tissue culture methods in laboratories.
   ii) A method of rapid multiplication of endangered plants.

d. Cryopreservation – A technique to preserve embryos, animals cells spermatozoa etc., at - 196^{o} C.

WILD LIFE

1. **IUCN-**
   a) International Union for the Conservation of Nature and Natural Resources (or World Conservation Union)
   b) An International organization founded in 1948.
2. **IUCN Red List (or "Red Data List") –**
   a) Created in 1963
   b) Maintained by IUCN.
   c) Latest update is 2006 Red List, released on May 4^{th}, 2006.
   d) It evaluates 40,168 species and an additional 2,160 subspecies or varieties.
   e) 16,118 species are considered threatened.
   f) 7,725 are animals, 8,390 are plants, 3 are lichens and mushrooms.
   g) Number of categories into which species are classified by IUCN Red List is 9 (on the criteria of rate of decline, population size, area of geographic distribution etc.,

      i) Extinct (Ex) – If the last individual of a species died. e.g. Dodo bird.

      ii) Extinct in the wild (EW) - If a species is known to survive only in cultivation or in captivity.

      iii) Critically Endangered (CR) – If a species is facing an extremely high risk of extinction in the wild in immediate future. e.g. *Podophyllum, Berberis nilgiriensis* .

iv) Endangered (EN) – If a species is not critically endangered, but is facing a high risk of extinction in the wild in near future. e.g. Red panda, Lion tailed Macaque.

v) Vulnerable (VU) – If a species is neither critically endangered or endangered, but is facing a high risk of extinction in the wild in the medium-term future. e.g. *Antelope cervicapra*.

vi) Near Threatened (NT) – When a species is not qualified for conservation dependent but closer to vulnerable.

vii) Least Concern(LC) – When a species do not qualify for conservation dependent or near threatened

viii) Data Deficient (DD) – A species with inadequate information to make an assessment based on its distribution and population status.

ix) Not Evalued (NE) – A species which is not yet been assessed against the criteria.

WILD LIFE IN INDIA

– India accounts for 7.31% of global fauna (89,451 species)

1) Biomes **(3)** – a) Tropical humid forest.
   b) Tropical dry/ deciduous forests.
   c) Warm deserts / semi-deserts .
2) Hot spots **(3)** - a) Western Ghats / Sri Lnaka
   b) Indo –Burma region (covering Eastern Himalayas).
   c) Himalayan region.
3) Eco regions **(10)**
   a) Trans – Himalayan b) The Himalayan c) The Indian Desert
   d) The semiarid zone(s) e) The western Ghats f) The Deccan Peninsula
   g) The Gangetic Plain h) North East India i) Islands j) Coasts.
4) Number of centres of origin of cultivated plants **-12.**
5) World heritage sites of biodiversity in India**(5)**
   a) Khaziranga National Park, Assam
   b) Manas National Park, Assam.
   c) Sunderbans National Park, West Bengal
   d) Keoladeo Ghana National Park, Rajasthan.
   e) Nanda Devi National Park, UttaraKhand.
6) Number of biosphere reserves – **14**.
7) Number of Ramsar wet lands – **6,** (Kolleru Lake of A.P is one among 6).
8) Number of National parks – **88**.
9) Number of Sanctuaries – **490** (covering an area of 1.53 lakh sq.km.).
10) Number of biosphere reserves of India that form a part of world net work – **4**
   a) Nilgiri biosphere reserve b) Nanda Devi biosphere reserve
   c) Sunderbans biosphere reserved) Gulf of Mannar biosphere reserve.
11) Endemism –
   a) 33% of endemic flora is mainly in
      i) North East region ii) Western Ghats

iii) North – west Himalayas iv) Andaman and Nicobar islands.

b) 62% of endemic amphibian species are present in Western Ghats.
c) 50% of endemic lizards are present in Western Ghats.
d) India is homeland of 167 cultivated species and 320 wild relatives of crop plants.

WILD LIFE CONSERVATION IN INDIA.

1. Wild life Protection Act 1972 – Act under which all threatened species are protected.
2. IBW and WWF – Organizations which work together for conservation of wild life.
3. Wild life week – First week of October.
4. a) IBW (Indian Board of wildlife) – Advisory body to Government of India.
   b) WWF (World Wild life Fund) for nature.
5. Acts related to wild life conservation in India –
   a) Indian Forest Act, 1927.
   b) The wild life (Protection) Act, 1972
   c) The Forest Conservation Act, 1980.
   d) The Air Act, 1980.
   e) The Environment (Protection) Act, 1986.
6. CITES (Convention on International Trade in Endangered Species) – India is a signatory to and a partner of it in 1976.
7. National Parks in India –
   a) Jim Corbett National Park – Uttaranchal (first National park,tigers are protected)
   b) Gir National Park – Gujarat (Lions are protected).
   c) Kanha National Park – Madhya Pradesh.
   d) Kaziranga National Park – Assam (One – horned Rhinoceros is protected)
   e) Periyar National Park – Kerala (A tiger and an elephant reserve)
   f) Sri Venkateswara National Park – Andhra Pradesh.
   g) Brahmananda Reddy National Park - Andhra Pradesh.
   h) Mahavir Harina Vanasthali National Park – Andhra Pradesh.
8. Sanctuaries in India –
   i. Ranthambore Sanctuary – Rajasthan
   ii. Mudumalai Sanctuary – Tamil Nadu
   iii. Papikonda Sanctuary – Andhra Pradesh.
   iv. Eturunagaram Sanctuary – Andhra Pradesh.
   v. Pulicat Sanctuary – Andhra Pradesh and Tamil Nadu.
   vi. Coringa Sanctuary – Andhra Pradesh.
   vii. Nagarjunasagar Srisailam Sanctuary – Andhra Pradesh
9. Protected areas near water bodies for migratory birds during certain season –
   a) Kolleru lake – A.P
   b) Ranganthttu Bird Sanctuary – Karnataka
   c) Bharatpur Bird Sanctuary (Now as Keoladeo Ghana National Park) - Rajasthan.
10. Biosphere Reserves in India-
   a) Nilgiri – Karnataka, Kerala and Tamil Nadu.
   b) Nanda Devi – Uttarakhand
   c) Sunderbans – West Bengal
   d) Gulf of Mannar – Tamil Nadu

e) Manas - Assam
f) Great Nicobar – Andaman and Nicobar Islands
g) Thar Desert – Rajasthan
h) Little Rann of Kutch – Gujarat.

11. Special Projects for Endangered species-
    A) Project Tiger → To protect Tiger (*Panthera tigris tigris*) in Tiger reserves.
    Tiger reserves (**15**) –
        a) Indravati Tiger Reserve – Chattisgarh
        b) Nagarjuna Srisailam Tiger Reserve – Andhra Pradesh.
    B) Crocodile Breeding Project – World's first captive breeding of crocodiles→ at Tikerpada, Orissa.
        a) Brakish water crocodile – *Crocodylus porosus*.
        b) Fresh water swamp crocodile – C. *palustris*.
        c) River crocodile – *Gavialis gangeticus*.
    C) Rhino conservation – Started in Assam.

    D) Snow – leopard (*Uncia uncia*) – In snow leopard reserve of Himalayas.

    E) Project Elephant – To protect Asiatic elephant *Elephas maximus indicus* in Periyar National Park → Kerala.

    F) Asiatic lion(*Panthera leo persica*) – Protected in Gir National Park.
12. Organizations in India
    a) BSI – Botanical Survey of India.
    b) ZSI – Zoological Survey of India.
    c) BNHS – Bombay Natural History Society.
    d) ICRISAT – International Crops Research Institute for the Semi-Arid Tropicsin Hyderabad (for conserving germplasm of ground nuts, pigeon pea, chick pea, pearl millet and sorghum).
    e) Wildlife Protection Society of India – Dehradun.
13. Endangered species in India-
    a) The Asiatic lion - *Panthera leo persica*.
    b) The black buck (State Animal of Andhra Pradesh) – *Antelope cervicapra*
    c) Red panda – *Ailurus ochraceus*
    d) The lion tailed macaque – *Macaca silenus*
    e) Tiger - *Panthera tigris*
    f) Elephant - *Elephas maximus indicus*
    g) Kashmiri stag – *Cervus elaphus hanglu*
    h) Pygmy hog – *Sus salvanius*
    i) Siberian crane – *Grus leucogeranus*
    j) The slender loris – *Loris tardigradus*

ENVIRONMENTAL ISSUES

- **Pollution** is any undesirable change in physical, chemical or biological characteristics of air, land, water or soil.
- Agents that bring about such an undesirable change are called as **pollutants.**

- In order to control environmental pollution, the Government of India has passed the **Environment (Protection) Act, 1986** to protect and improve the quality of our environment (air, water and soil).

Air Pollution And Its Control

- Air pollutants cause injury to all living organisms. They reduce growth and yield of crops and cause premature death of plants.
- Air pollutants also deleteriously affect the respiratory system of humans and of animals.
- Harmful effects depend on the concentration of pollutants, duration of exposure and the organism.
- Smokestacks of thermal power plants, smelters and other industries release particulate and gaseous air pollutants together with harmless gases, such as nitrogen, oxygen, etc.
- There are several ways of removing particulate matter; the most widely used of which is the **electrostatic precipitator.** which can remove over 99 per cent particulate matter present in the exhaust from a thermal power plant.
- Recently we have realised the dangers of particulate matter that are very very small and are not removed by these precipitators.
- According to Central Pollution Control Board (CPCB), particulate size 2.5 micrometers or less in diameter (PM 2.5) are responsible for causing the greatest harm to human health.
- These fine particulates can be inhaled deep into the lungs and can cause breathing and respiratory symptoms, irritation, inflammations and damage to the lungs and premature deaths.
- Proper maintenance of automobiles along with use of lead-free petrol or diesel can reduce the pollutants they emit.
- Catalytic converters, having expensive metals namely platinum-palladium and rhodium as the catalysts, are fitted into automobiles for reducing emission of poisonous gases.
- Vehicular Air Pollution Controlled by compressed natural gas (CNG) which is cheaper than petrol or diesel.
- The Bharat Stage II (equivalent to Euro-II norms), which is currently in place in Delhi, Mumbai, Kolkata, Chennai, Bangalore, Hyderabad, Ahmedabad, Pune, Surat, Kanpur and Agra, will be applicable to all automobiles throughout the country from April 1, 2005.
- All automobiles and fuel-petrol and diesel – were to have met the Euro III emission specifications in these 11 cities from April 1, 2005 and have to meet the Euro-IV norms by April 1, 2010.
- The rest of the country will have Euro-III emission norm compliant automobiles and fuels by 2010.
- In India, the **Air (Prevention and Control of Pollution) Act** came into force in 1981, but was amended in 1987 to include noise as an air pollutant.
- **Noise** is undesired high level of sound. We have got used to associating loud sounds with pleasure and entertainment not realizing that noise causes psychological and physiological disorders in humans.

- The bigger the city, the bigger the function, the greater the noise!! A brief exposure to extremely high sound level, 150 dB or more generated by take off of a jet plane or rocket, may damage ear drums thus permanently impairing hearing ability.
- Noise also causes sleeplessness, increased heart beating, altered breathing pattern, thus considerably stressing humans.

Water Pollution And Its Control

- The Government of India has passed the **Water (Prevention and Control of Pollution) Act, 1974** to safeguard our water resources.
- Presence of large amounts of nutrients in waters also causes excessive growth of **planktonic** algae, called an **algal bloom** which imparts a distinct colour to the water bodies.
- Algal blooms cause deterioration of the water quality and fish mortality.
- Plants like water hyacinth (*Eichhornia crassipes),* the world's most problematic aquatic weed, also called 'Terror of Bengal'. They grow abundantly in eutrophic water bodies, and lead to an imbalance in the ecosystem dynamics of the water body.
- Biomagnification refers to increase in concentration of the toxicant at successive trophic levels.
- **Eutrophication** is the natural aging of a lake by biological enrichment of its water.
- Wastewater including sewage can be treated in an integrated manner, by utilising a mix of artificial and natural processes.
- An example of such an initiative is the town of Arcata, situated along the northern coast of California. Collaborating with biologists from the Humboldt State University, the townspeople created an integrated waste water treatment process within a natural system.

Solid Wastes

- **Solid wastes** refer to everything that goes out in trash. **Municipal solid wastes** are wastes from homes, offices, stores, schools, hospitals, etc.
- The municipal solid wastes generally comprise paper, food wastes, plastics, glass, metals, rubber, leather, textile, etc.
- **Sanitary landfills** were adopted as the substitute for open-burning dumps. In a sanitary landfill, wastes are dumped in a depression or trench after compaction, and covered with dirt everyday.
- All waste that we generate can be categorised into three types – (a) bio-degradable, (b) recyclable and (c) the non-biodegradable.
- A plastic sack manufacturer in Bangalore has managed to find the ideal solution to the ever- increasing problem of accumulating plastic waste.
- Hospitals generate hazardous wastes that contain disinfectants and other harmful chemicals, and also pathogenic micro-organisms. Such wastes also require careful treatment and disposal. The use of incinerators is crucial to disposal of hospital waste.
- Irreparable computers and other electronic goods are known as **electronic wastes** (**e-wastes**). E-wastes are buried in landfills or incinerated.

Radioactive Wastes

- Initially, nuclear energy was hailed as a non-polluting way for generating electricity. Later on, it was realised that the use of nuclear energy has twovery serious inherent problems. The first is accidental leakage, as occurredin the Three Mile Island and Chernobyl incidents and the second is safe disposal of radioactive wastes.
- Radiation, that is given off by nuclear waste is extremely damaging to biological organisms, because it causes mutations to occur at a very high rate.
- At high doses, nuclear radiation is lethal but at lower doses, it creates various disorders, the most frequent of all being cancer.
- Therefore, nuclear waste is an extremely potent pollutant and has to be dealt with utmost caution.
- It has been recommended that storage of nuclear waste, after sufficient pre-treatment, should be done in suitably shielded containers buried within the rocks, about 500 m deep below the earth's surface.

Greenhouse Effect And Global Warming

- The term 'Greenhouse effect' has been derived from a phenomenon that occurs in a greenhouse.
- The greenhouse effect is a naturally occurring phenomenon that is responsible for heating of Earth's surface and atmosphere. You would be surprised to know that without greenhouse effect the average temperature at surface of Earth would have been a chilly –18$_o$C rather than the present average of 15$_o$C.
- carbon dioxide and methane – are commonly known as greenhouse gases because they are responsible for the greenhouse effect.
- Increase in the level of greenhouse gases has led to considerable heating of Earth leading to global warming.
- During the past century, the temperature of Earth has increased by 0.6 $_o$C, most of it during the last three decades.
- Scientists believe that this rise in temperature is leading to deleterious changes in the environment and resulting in odd climaticchanges.
- increased melting of polar ice caps as well as of other places like the Himalayan snow caps. Over many years, this will result in a rise in sea level that can submerge many coastal areas.

Ozone Depletion

- Good ozone is found in the upper part of the atmosphere called the **stratosphere**, and it acts as a shield absorbing ultraviolet radiation from the sun.
- UV rays are highly injurious to living organisms since DNA and proteins of living organisms preferentially absorb UV rays, and its high energy breaks the chemical bonds within these molecules.
- The thickness of the ozone in a column of air from the ground to the top of the atmosphere is measured in terms of **Dobson units** (DU).
- Ozone gas is continuously formed by the action of UV rays on molecular oxygen, and also degraded into molecular oxygen in the stratosphere.

- There should be a balance between production and degradation of ozone in the stratosphere. Of late, the balance has been disrupted due to enhancement of ozone degradation by **chlorofluorocarbons** (**CFC**s).
- CFCs find wide use as refrigerants. CFCs discharged in the lower part of atmosphere move upward and reach stratosphere.
- In stratosphere, UV rays act on them releasing Cl atoms. Cl degrades ozone releasing molecular oxygen, with these atoms acting merely as catalysts; Cl atoms are not consumed in the reaction.
- Hence, whatever CFCs are added to the stratosphere, they have permanent and continuing affects on Ozone levels. Although ozone depletion is occurring widely in the stratosphere, the depletion is particularly marked over the Antarctic region.
- This has resulted in formation of a large area of thinned ozone layer, commonly called as the **ozone hole**.
- UV radiation of wavelengths shorter than UV-B, are almost completely absorbed by Earth's atmosphere, given that the ozone layer is intact. But, UV-B damages DNA and mutation may occur.
- It causes aging of skin, damage to skin cells and various types of skin cancers.
- In human eye, cornea absorbs UV-B radiation, and a high dose of UV-B causes inflammation of cornea, called **snow-blindness** cataract, etc. Such exposure may permanently damage the cornea.
- Recognising the deleterious affects of ozone depletion, an international treaty, known as the **Montreal Protocol**, was signed at Montreal (Canada) in 1987 (effective in 1989) to control the emission of ozone depleting substances.

Deforestation

- Deforestation is the conversion of forested areas to non-forested ones.
- According to an estimate, almost 40 per cent forests have been lost in the tropics, compared to only 1 per cent in the temperate region.
- The present scenario of deforestation is particularly grim in India. At the beginning of the twentieth century, forests covered about 30 per cent of the land of India. By the end of the century, it shrunk to 19.4 per cent, whereas the National Forest Policy (1988) of India has recommended 33 per cent forest cover for the plains and 67 per cent for the hills.
- **Slash and burn agriculture**, commonly called as **Jhum cultivation** in the north-eastern states of India, has also contributed to deforestation.
- **Reforestation** is the process of restoring a forest that once existed but was removed at some point of time in the past. Reforestation may occur naturally in a deforested area.

Case Study of People's Participation in Conservation of Forests

- In 1731, the king of Jodhpur in Rajasthan asked one of his ministers to arrange wood for constructing a new palace. The minister and workers went to a forest near a village, inhabited by Bishnois, to cut down trees. The Bishnoi community is known for its peaceful co-existence with nature. The effort to cut down trees by the kings was thwarted by the Bishnois. A Bishnoi woman Amrita Devi showed exemplary courage by hugging a tree and daring king's men to cut her first before cutting the tree. The tree mattered much more to her than her own life. Sadly, the king's men did not heed to her pleas, and cut down the tree along with Amrita Devi. Her three daughters and hundreds of other Bishnois followed her, and thus lost their lives saving trees. Nowhere in history do we find a commitment of this magnitude when human beings sacrificed their lives for the cause of the environment.

- The Government of India has recently instituted the **Amrita Devi Bishnoi Wildlife Protection Award** for individuals or communities from rural areas that have shown extraordinary courage and dedication in protecting wildlife.
- **Chipko Movement** of Garhwal Himalayas in 1974, local women showed enormous bravery in protecting trees from the axe of contractors by hugging them. People all over the world have acclaimed the Chipko movement.
- Realising the significance of participation by local communities, the Government of India in 1980s has introduced the concept of **Joint Forest Management** (**JFM**).

MULTIPLE CHOICE QUESTIONS

1. Synecology is also called
   1) Limnology 2) Ecology of communities 3) Species ecology 4) Autecology
2. The polar ice caps on the earth are a part of
   1) Atmosphere 2) Hydrosphere 3) Lithosphere 4) Biome
3. Thickness of mantle of lithosphere is
   1) 2900 Km 2) 6900 Km 3) 7000 Km 4) 30 Km
4. Taiga is the biome in
   1) The Antarctica 2) The arctic region
   3) The temperature regions 4) The tropical regions
5. Larvae of *Pinnotheres maculatus* move faster with
   1) Increasing humidity 2) Increasing light intensity
   3) Decreasing light intensity 4) Increasing temperature
6. Prolonged exposure of animals to U.V. rays can cause
   1) Lung cancer 2) Colic cancer 3) Blood cancer 4) Skin cancer
7. Palolo worms exhibit
   1) Lunar periodicity 2) Solar periodicity 3) Photokinesis 4) Phototaxis
8. Biological clocks are influenced by
   1) Temperature 2) Humidity 3) Light 4) Rainfall
9. In thermocline the temperature decreases rapidly at the rate of
   1) 10^0C per meter of depth 2) 1^0C per 10 meters of depth
   3) 1^0C per meter of depth 4) 2^0C per meter of depth
10. The circulation of water in the lakes of temperature regions is called
    1) Overturn 2) Compensation 3) Stagnation 4) Stratification

11. Q_{10} for an enzyme controlled reaction is
   1) Approximately 2 2) Approximately 10
   3) Approximately 3 4) Approximately 5a

12. Latent heat of fusion of water is
   1) 80 calories 2) 80 joules 3) 80 kilocalories 4) 80 kilojoules

13. Salts which are lost from the body fluids along with urine, are regained by active uptake from the water by
   1) Chloride cells in the gills of fresh water fishes
   2) Chloride cells in the gills of marine fishes
   3) Salt glands of sea gulls and penguins 4) Salt glands of giant turtle

14. Salt gland ducts open near the eyes in
   1) Giant turtle 2) Giant tortoise 3) Sea gull 4) Penguin

15. Cleidoic eggs are layed by
   1) Fresh water animals 2) Brackish water animals
   3) Terrestrial animals 4) Marine animals

16. The flow of energy in ecosystem is
   1) Unidirectional 2) Bidirectional 3) Multidirectional 4) Cyclic

17. When a herbivore digests 75% of NPP ingested and its assimilation efficiency is 15% of NPP, amount of NPP ingested is
   1) 100% 2) 50% 3) 20% 4) 2%

18. Every predator food chain begins with
   1) A predator 2) A prey 3) The decomposers 4) The producers

19. Consider the following
   Phytoplankton → ***?*** → *Small fish* → *Squid* → *Seal*
   The primary consumer in the box is
   1) Grasshopper 2) Rat 3) Aphids 4) Zooplankton

20. This ecological pyramid is inverted
   1) Energy pyramid of parasitic food chain
   2) Biomass pyramid of parasitic food chain
   3) Number pyramid of parasitic food chain
   4) Number pyramid of predator food chain

21. Amphibious plants of littoral zone in a lake
   1) Emergent vegetation 2) Floating vegetation
   3) Phytoplankton 4) Submerged vegetation

22. Open water zone of a lake is
   1) Littoral zone 2) Limnetic zone 3) Profundal zone 4) Aphotic zone

23. The growth and decline in the size of a population over a period of time, under given environmental conditions can be represented graphically in the form of

1) Age pyramids 2) Growth curves
3) Number pyramids 4) Ecological pyramids

24. In sigmoid growth curve, zero population growth phase occurs immediately after
1) Logarithmic phase 2) Lag phase
3) Positive acceleration phase 4) Negative acceleration phase

25. The growth curve of algal blooms is
1) S-shaped growth curve 2) Density dependent growth curve
3) J-shaped growth curve 4) Logistic growth curve

26. Intrinsic factors of population regulation
1) Competition and predation 2) Migration and diseases
3) Territorial behavior 4) All these

27. Simplest measure of biodiversity is
1) The species richness 2) The species endemism
3) The beta diversity 4) The gamma diversity

28. Species diversity between ecosystem is
1) Delta diversity 2) Beta diversity
3) Alpha diversity 4) Gamma diversity

29. Vincristin and Vinblastin are
1) Antihypertensive drugs 2) Anticancer drugs
3) Antimalaria drugs 4) Pain relieving drugs

30. *Clavaria major* seeds germinate when pass through the abrasive gut of
1) Ostrich bird 2) Dodo bird 3) Kiwi bird 4) Emu bird

31. In quite a short period if species disappear on Earth due to human activities it is called
1) Mass extinction 2) Natural extinction
3) Anthropogenic extinction 4) Background extinction

32. Onsite conservation is
1) In-situ conservation 2) In-vitro conservation
3) In-vivo conservation 4) Ex-situ conservation

33. The earliest National Park in USA is
1) Yellow stone National Park 2) Royal National Park
3) Jim Corbett National Park 4) Gir National Park

34. An undisturbed and legally protected area of an ecosystem is
1) Core zone 2) Buffer zone
3) Transitional zone 4) Manipulation zone

35. Coconut, Cocoa, Tea, Jackfruit etc., are stored in
1) Orthodox seed banks 2) Recalcitrant seed banks 3) Both 4) None

36. Gharial is
1) *Gavialis gangeticus* 2) *Crocodylus palustris*
3) *Tylatotriton verrucosus* 4) *Crocodylus porosus*

37. Dodo is

1) Extinct in the wild
2) Critically Endangered
3) Extinct
4) Endangered

38. Endangered animal species of India among the following
1) *Macaca silenus*
2) *Antelope cervicapra*
3) *Felis bengalensis*
4) *Gavialis gangeticus*

39. Sunderbans National Park World heritage site is located in this state of India
1) Andhra Pradesh 2) West Bengal 3) Uttarakhand 4) Jharkhand

40. Tigers are protected in this National Park
1) Jim Corbett National Park
2) Kaziranga National Park
3) Gir National Park
4) Sri Venkateswara National Park

41. EL NINO is due to
1) Unusual rains and floods
2) Unusual dry spells
3) Variation in temperature of sea water
4) Variation in temperature of Lake waters

STATEMENTS

1. The following are the statements about biological rhythms
   I. Biorhythms with a periodicity of about 24 hours are called circadian rhythms
   II. Migration of Siberian birds to India during winter is an example for diurnal migrations.
   III. Lunar periodicity of *Eunice viridis* is a kind of biorhythm.
   IV. The nocturnal habits of mosquitoes, cockroaches, rats and owls are circadian rhythms.
   V. The vertical migrations of zooplanktonic organisms into deeper waters during the daytime and their migrations to the surface waters during the night time are called circannual migrations.

   Identify the correct statements:
   1) All 2) I, II and III 3) III, IV and V 4) I, III and IV

2. Study the following statements about population regulation
   I. Populations have an inherent capacity to grow in size
   II. Populations can increase indefinitely
   III. Extrinsic environmental factors regulating the populations are density independent factors.
   IV. Intrinsic environmental factors regulating the populations are natality, mortality, emigration, immigration etc.,

   Which of the above are correct?
   1) All except II 2) All 3) I & III 4) I , II & III

3. Study the following statements
   I. The Indian Board of Wildlife works in collaboration with the WCU
   II. To protect the wildlife, The Wildlife (Protection) Act was enacted in India in 1982
   III. 1st of October is observed as wildlife day.

In the above
1) All are wrong
2) All are correct
3) Only I is wrong
4) Only III is wrong

TWO COLUMNS MATCHING

1. Match the following and select the correct option.

Rule	Applicable to	The Correct Match is
A. Bergmann's rule B. Van't Hoff's rule C. Jordan's rule D. Allen's rule	I. Segmentation in fishes II. Pigmentation in the skin III. Body size of warm blooded animals IV. Biochemical reactions of cold blooded animals V. Size of extremities of body of mammals	A B C D 1) III IV I II 2) V IV I III 3) III I IV V 4) III IV I V

2. Match the following and select the correct option.

List–I	List–II	The Correct Match is
A. Natality	I. Inward movement of individuals into the population from neighbouring areas	A B C D 1) IV III I II 2) III IV II I 3) IV III II I 4) IV II III I
B. Mortality	II. Outward movement of individuals from a population to another area	
C. Emigration	III. The number of deaths per year per thousand	
D. Immigration	IV. The number of births per year per thousand	

3. Match the following.

List–I	List–II	The Correct Match is
A. Urn shaped pyramid B. Inverted triangular pyramid C. Triangular pyramid D. Bell shaped pyramid	I. Parasitic food chain numbers pyramid II. Energy pyramid III. Age pyramid of growing population IV. Age pyramid of declining population V. Pyramid of biomass in a pond VI. Age pyramid of stable population	A B C D 1) IV I II VI 2) VI V II IV 3) IV I III VI 4) IV V III VI

4. Match the following and select the correct option.

List–I	List–II	The Correct Match is
A. Vinblastin B. Quinine C. Morphine D. Digitalin E. Reserpine	I. Used to treat malaria II. Pain relief drug III. Used to treat chronic heart trouble IV. Anticancer drug V. Antihypertensive drug	A B C D E 1) V I II IV III 2) IV I II III V 3) IV V II I III 4) III II V IV I

5. Match the following and select the correct option.

List–I	List–II	The Correct Match is
A. Critically endangered species B. Vulnerable species C. Endangered species D. Rare species	I. *Cupressus cashmeriana* II. *Podophyllum* III. *Rhinoceros unicornis* IV. *Tylatotriton verrucosus*	A B C D 1) II I III IV 2) IV III II I 3) IV II I III 4) III I IV II

6. Match the following and select the correct option.

List–I	List–II	The Correct Match is
A. Kolleru lake B. Ranganna Theethu Bird Sanctuary C. Bharatpur Bird Sanctuary D. Indravathi Tiger Reserve	I. Rajasthan II. Karnataka III. A.P. IV. Chattishgarh	A B C D 1) III I II IV 2) III II I IV 3) IV II I III 4) III II IV I

THREE COLUMNS MATCHING

1. Study the following about the rules of temperature

Rule	Applicable to	Explains the effect of temperature on
I. Bergmann's rule	Warm blooded animals	The size of body extremities
II. Allen's rule	Mammals	Body size
III. Jordan's rule	Fishes like cods	Early segmentation in the development
IV. Gloger's rule	Animals	Pigmentation

Which of the above are correct?

1) I and II 2) II and III 3) III and IV 4) All

2. Study the following regarding the consumers of littoral zone of lake

Kind	Characters	Example
I. Nekton II. Neuston III. Periphyton IV. Benthos	Animals living at the air and water interface Animals capable of swimming Animals attached to the aquatic plants Animals resting on or moving on the bottom	*Ranatra* *Gerris* *Limnaea* *Lamellidens*

Which of the above are correct?
1) III and IV 2) II, III and IV 3) I, II and III 4) All

3. Study the following regarding IUCN Red List categories.

Category	Description	Example
I. Extinct	Last individual has died	Dodo
II. Not evaluated	Not yet been assessed against the criteria	*Clavaria major*
III. Endangered	Facing a high risk of extinction in the wild in the near future	*Ailurus ochraceus*
IV. Least concern	Do not qualify for conservation dependent or near the threatened	*Cupressus cashmeriana*

Identify the correct combinations.
1) I and II 2) I and III 3) II and IV 4) III and IV

4. Study the following.

I. Pulicat	Biosphere Reserve	A.P.
II. Ranthambhor	Sanctuary	Rajasthan
III. Kanha	National Park	M.P.
IV. Dibru Saikhowa	Biosphere Reserve	Assam

Which of the above are correct?
1) I, II and III 2) II, III and IV 3) I, III and IV 4) I, II and IV

SEQUENCE

1. The following are various levels of productivity
A) NPP B) GPP C) GSP D) NSP
Arrange these in a correct sequence
1) B–C–A–D 2) B–A–C–D 3) A–D–B–C 4) C–B–D–A

2. The following are the rooted plants in a lake
A) Submerged vegetation B) Emergent vegetation
C) Floating vegetation
Arrange these in a correct sequence from shore
1) A–C–B 2) B–C–A 3) B–A–C 4) C–A–B

3. The following are various phases in the growth curves of populations
A) Stabilization phase B) Crash C) Negative acceleration phase
D) Logarithmic phase E) Positive acceleration phase
Arrange these in the correct sequence of density independent growth curve
1) E–D–B 2) E–D–C–B 3) E–D–B–C–A 4) E–D–C–A

4. The following are various categories of species as per IUCN Red List
A) Least concern B) Critically endangered C) Vulnerable
Arrange these categories in the increasing order of threat of extinction they face
1) B–C–A 2) C–A–B 3) A–B–C 4) A–C–B

ASSERTION AND REASON

Instructions:-

Select the option & mark the correct number accordingly.

a) Both A & R are true & R is correct explanation of A
b) Both A & R are true but R is not correct explanation of A
c) A is true & R is false
d) A is false & R is true
e) Both A & R are false

1. Assertion (A): Migration of Siberian birds to India every year is a biological rhythm
   Reason (R): Siberian birds migrate to India at regular intervals precisely at the same time i.e. winter
   1) e 2) a 3) b 4) c

2. Assertion (A): In the winter stagnation, the oxygen content of water is not depleted and the organisms are not subjected to hypoxia.
   Reason (R): In the winter stratification, photosynthetic activity in aquatic producers increases
   1) a 2) b 3) c 4) e

3. Assertion (A): Water has great capacity for absorbing heat with only minimal change in the temperature.
   Reason (R): Water has high specific heat
   1) a 2) b 3) c 4) e

4. Assertion (A): The growth of the aphids is density independent.
   Reason (R): When the weather is favourable crash occurs in aphids
   1) a 2) e 3) d 4) c

5. Assertion (A): Forests reduce atmospheric pollution.
   Reason (R): Forests remove CO and CO_2 from the atmosphere.
   1) b 2) c 3) a 4) d

KEY

MULTIPLE CHOICE QUESTIONS

1) 2	2) 2	3) 1	4) 3	5) 2	6) 4	7) 1	8) 3
9) 3	10) 1	11) 1	12) 1	13) 1	14) 1	15) 3	16) 1
17) 3	18) 4	19) 4	20) 3	21) 1	22) 2	23) 2	24) 4
25) 3	26) 4	27) 1	28) 2	29) 2	30) 2	31) 3	32) 1
33) 1	34) 1	35) 2	36) 1	37) 3	38) 1	39) 2	40) 1
41) 3							

STATEMENTS

1) 4	2) 3	3) 1

TWO COLUMNS MATCHING

1) 4	2) 3	3) 3	4) 2	5) 1	6) 2

THREE COLUMNS MATCHING

1) 3	2) 1	3) 2	4) 2

SEQUENCE

1) 2	2) 2	3) 1	4) 4

ASSERTION & REASON

1) 2	2) 3	3) 1	4) 4	5) 3

Unit-VIII
PLANT PHYSIOLOGY

SOIL

- Soil is the main substratum on which plants grows. It influences all the stages of plant life & gives mechanical strength to plants
- It provides water & nutrients to the plants
- Soil affects seed germination, depth of root system, size & erectness of plant, woodiness of stem etc
- Soil is one of the important ecological factor which is known as "edaphic factor"
- Warming (1909) emphasised the importance of soil characteristics & proposed 5 groups of plants. They are ----

Ecological Group	Soil Character
Halophytes	Plants growing on saline soils
Oxylophytes	Plants growing on acid soil
Psammophytes	Plants growing on sand
Lithophytes	Plants growing on rock surface
Chasmophytes	Plants growing in crevices of rocks

- Soil is defined as "superficial layer of earth's crust on which plants grows".
- The term 'Soil' is derived from Latin word 'Solum' which means floor or substratum
- The study of soil is known as pedology or edaphalogy or soil science
- Soil is formed as a result of complex interaction that takes place in prolonged time
- 'Soil complex' is formed when soil is associated with living as well as dead organic matter
- Soil is formed as a result of disintegration of parent rock (i.e. regolith) by a process called weathering
- The process of soil formation is known as pedogenesis
- Weathering may be mechanical, chemical or biological

<u>Mechanical Weathering</u>: "parent rock breaks into small particles due to several natural factors like rain, wind, temperature, frost, moving glaciers" etc

<u>Chemical Weathering</u>: "Disintegration of parent rock into small particles by the oxidation, reduction, hydration, hydrolysis & carbonation of parent rock".

<u>Biological Weathering</u>: "disintegration of parent rock into small particles by living organisms". Lichens grows on bare rocks & produce carbonic acid that corrode the rocks; hence they are pioneers of plant succession

<u>Classification of Soil</u>: on the basis of origin, soils are classified into two categories.

i) Residual Soil ii) Transported Soil

<u>Residual Soil</u>: Soil formed from parent rock in a place is called as residual soil.

<u>Transported Soil</u>: Soil formed from parent rock which is carried from its place of origin by various agents is called as transported soil.

- Transported soils are of different types

a) <u>Colluvial Soil</u>: Transported soil is formed from parent rock is moved by gravitational pull.

b) <u>Alluvial Soil</u>: Transported soil is formed from parent rock is moved by running water

c) <u>Eolian Soil</u>: Transported soil is formed from parent rock is moved by wind

d) <u>Glacial Soil</u>: Transported soil is formed from parent rock is moved by glaciers

<u>Soil Profile</u>:

- Parent rock disintegrate slowly but continuously & form the soil. Climatic factors & soil organisms also acts slowly on parent rock to form soil. Thus soil is stratified layer showing different horizons
- Soil profile, may be defined as "vertical section of earth's crust which exposes different layers of soil".
- It shows 3 different zones or horizons.

  Horizon – A →Top soil
  Horizon –B →Sub –soil   } True soil or Solum
  Horizon –C→Regolith soil

Horizon – A:
- It is the top most layer of soil profile & is also known as top soil.
- It consists of mineral & organic matter which are mixed with fine soil particles.
- It is rich in humus & is dark colured.
- It's thickness varies from few centimeters to one or two meters
- It supports vegetation & soil micro – organisms
- Top soil is most suitable for plant growth

Horizon –B:
- It is the middle layer of soil profile & is also known as sub – soil. It is about one meter thick.
- It is light in colour. It consists of disintegrating parent rock, mineral deposits & organic residues.
- It is coarse in texture because of the presence of more amount of clay particles
- It acts as water reservoir but aeration is less. Biological activity is also very less
- Top soil & sub – soil together forms a dynamic system & constitute "true soil" or "Solum". True soil supports soil flora, soil fauna & soil micro – organisms

Horizon –C:
- It is the lower most layer of soil profile & is also known as regolith zone
- It consists of parent rock material called regolith & other materials
- It is not fertile. Soil microbs are absent in this region

COMPONENTS OF SOIL: Soil consists of five different components of soil.
They are ----

1) Mineral Matter   2) Organic matter   3) Soil Air
4) Soil Water   5) Soil Organisms

MINERAL MATTER:
- Soil consists of different type of mineral particles
- Important mineral substances present in the soil are Calcite, Magnesite, Dolomite, Quartz, Silica, Mica, Feldspar (silicates of aluminum with either sodium, potassium or calcium), Iron oxides Kaoline etc
- Compounds of boron, magnesium, copper, iron, zinc, molybdium, cobalt are also present
- Sand, slit & clay are found in aggregated form known as peds where as artificial aggregates are known as clods
- Shape & size of peds plays an important role in the structure & aeration of soil
- "Internatal Society of Soil Science" proposed a classification of soil particles based on their size of soil particles

Soil Particle	Size / Diameter
Coarse Graval	- more than 5mm
Fine Gravel	-2 –5 mm
Coarse Sand	- 0.2 – 2 mm

Fine Sand	- 0.02 –0.2mm
Silt	- 0.002 –0.02 mm
Clay	- less than 0.002mm

- Aeration & water holding capacity depends upon the size of soil particle
- Aeration increases with the increase in size of soil particle but water holding capacity decreases
- The space left in unit volume of soil after accommodation of solid matter is called pore spaces

Types of Soil: Soil characteristic depends upon soil texture which constitute the size, proportion & arrangement of mineral particles & amount of organic matter

On the basis of texture, soils are classified into ----

a) Clayey soil   b) Sandy soil   c) Loam soil

a) Clayey Soil: (heavy soil)

- It consists of more than 90% of clay particles
- Clay particles are smaller in size & are arranged compactly due to which water holding capacity is high but aeration is very poor
- It provides greater surface area for microbial activity
- Clay particles when moist & shrinks & cracks when dry causing damage to the roots
- Clay particles are negatively charged & binds exchangeable cations to their surface preventing their leaching by rain water
- Clayey soils are good source of mineral nutrition for plants

b) Sandy Soils: (light soil)

- It consists of more than 80% of sand particles
- If the soil contains 100% of sand particles it is known as sand dunes, sand heaps & sand desert
- Sandy soil is loose, dry & different in minerals
- Pore spaces are large & hence aeration is very good but water holding capacity is very poor. Hence this soil is not suitable for plant growth

c) Loam Soil:

- It consists of sand, silt & clay particles in equal proportion
- It has high water holding capacity & good aeration
- It provides good surface area for microbial activity
- This soil is rich in minerals & is best soil for plant growth
- Loam soil with more sand particles – Sandy loan
- Loam soil with more clay particles – Clayey loam

2) ORGANIC MATTER:

- Soil contains 1 – 6 % of organic matter
- Freshly added organic matter to the soil consists of dead bodies of plants & animals, fallen leaves, twigs, animal excreta etc is known as “litter”
- Litter undergo decomposition by the activity of microbes like bacteria, fungi & protozoans
- Partially decomposed organic matter present beneath the litter is known as “duff”
- Duff further decomposes to form humus by the process of humification
- Humus is dark coloured, amorphous substance
- It is light in weight & consists of cellulose, peptides, aminoacids & other organic acids
- It increases water holding capacity, porosity & soil fertility
- Humus mix up with soil particles & undergo chemical decomposition to form minerals by the process of mineralisation thus helping in recycling of materials

Importance of Humus: Humus plays many important roles such as ----

- It increases water holding capacity
- It makes the soil fertile
- It provides nutrients to microbes & plants
- It increases porosity & increases aeration
- It increases percolation making the soil more suitable for plant growth
- It increases the availability of minerals in dissolved state to the plants

SOIL AIR: (Gaseous phase)

- The spaces present in between the soil particles is known as pore spaces
- Pore spaces are occupied by soil air, soil water & soil organisms
- The air or gases present in pore spaces constitute soil air or soil atmosphere
- It consists of Nitrogen, Oxygen, Carbondioxyde & other gases

  The composition of soil air & atmospheric air is ----

Gases	Volume in	
	Soil air	Atmospheric air
Oxygen	20%	21%
Nitrogen	78.6%	78.03%
Carbondioxide	0.5%	0.03%
Argon	0.9%	0.94%

- Oxygen concentration is less & CO_2 concentration is more in soil air when compared to atmospheric air
- Less oxygen concentration in the soil leads to the formation of pneumatophores in mangroves like Avicennia, Rhizophora etc & development of aerenchyma in hydrophytes

SOIL WATER:

- Presence of adequate amount of water in the soil is essential for normal growth of plants
- Water present in the soil is in the form of dilute solution which contains many minerals in dissolved state
- It regulates many physical chemical & biological activities of soil
- It maintains the nature of soil & compactness of the soil particles
- The main source of soil water is precipitation
- Different forms of precipitation are rainfall, snowfall, dew, mist etc
- Soil water exists in different forms such as -----

i) Run away water: The amount of rain water or irrigation water that flows on soil surface & is drained away is known as run away water. This form of water is not available to plants

ii) Gravitational water: The amount of water that percolates into the deeper layers of soil due to gravitational force is known as gravitational water. It reaches the ground water table & is not available to plants

iii) Hygroscopic water: This film of water which firmly attached to surface of soil particles due to strong intermolecular force of attraction is known as hygroscopic water. This form of water is not available to plants

iv) Capillary water: The water which occupies pore spaces present between soil particles against gravitational force is known as capillary water. It is the water which is available to plants. In a loam soil, the volume of capillary water is approximately half the volume of its gravitational water

- Total amount of water present in the soil is known as hollard
- The amount of water available to the plants is known as chresard
- Amount of water not available to the plants is known as echard

SOIL WATER CONSTANT: "The amount of water present in the soil after percolation of gravitational water is known as field capacity or water holding capacity".

- Field capacity is represented by capillary water & hygroscopic water
- It indicates soil moisture content useful for plants
- The soil comes to its field capacity in 1or 2 days after irrigation or good rain
- Field capacity of ----
  sandy soil is 5%
  loam soil is 25 – 35%
  clay soil is 45%
- The percentage of water at which the plant shows permanent witling is known as witling coefficient or permanent witling percentage (WC or PWP). It denotes the lower limit of soil water content useful for plants
- Water supplying capacity of soil can be estimated by substracting permanent witling percentage from field capacity WSC = FC – PWP

SOIL ORGANISMS (or) BIOLOGICAL SYSTEM:

- Different types of living organisms like Bacteria, Algae, Fungi, Protozoans, Nematodes, Annelida, Arthropoda, Mollusca, Rotifers etc
  These organisms constitutes biophase of soil
- Biophase includes both soil flora & soil fauna
- Soil organisms are found around rhizosphere
- The study of soil micro –organisms is known as soil microbiology
- Soil organisms forms a stable soil biological environment
- Soil atmosphere of irrigated loam soils is most suitable for the formation of stable soil biological environment
- Soil organisms may be beneficial or harmful Both the organisms shows effects on plant growth
- Some of the effects of soil organisms are -----

i) Saprophytic bacteria & fungi decompose the organic matter & increases soil fertility. They help in recycling of materials
ii) Nitrogen fixing prokaryotes of soil like Rhizobium, Azotobacter, Clostridium, Nostoc, Anabena etc converts atmosphere nitrogen into nitrogenous compounds & increases the nitrogen content of the soil
iii) Ammonifying & Nitrifying bacteria helps in the formation of Ammonia & Nitrates in the soil
iv) Mycorrhizae help in the absorption of water & nutrients in acids soils
v) Some bacteria & fungi secrete growth promoting substances which induce growth in plants
vi) Soil flora & fauna makes the soil more porous & better aerated
vii) Toxins secreted by microorganisms inhibit the growth of the plants
viii) Carbondioxide liberated by soil microorganisms may be toxic to plants
ix) Parasitic organisms present in the soil cause various diseases of plants & cause considerable loss to annual yield
x) Some soil organism secretes mucilage which binds soil particles into soil aggregates

NOTE:

- Nitrogen deficient soil is known as mor soil

- Nitrogen rich soil is known as mull soil
- Soil containing Iron & Aluminium ions is laterite soil
- Soil containing $CaCO_3$ is called as calcareous soil
- Soil contain more H^+ ions than OH^- ions are called acid soil
- Removal of top soil by wind, water etc is called soil erosion
- Formation of deserts is due to soil erosion by wind
- Formation of gulley is due to soil erosion by water
- Formation of landslides is due to soil erosion by gravity
- Soil erosion can be prevented by afforestation
- Total removal of vegetation in an area is called denudation
- Managing soil nature is called soil conservation
- Plants which appear as mesophytes in rainy season & as Xerophytes in summer are called as tropophytes

Absorption of Water

- Water is an essential components of all living organisms
- In plants water content varies from one tissue to another tissue, from one cell to another cell
- The water content is determined by environmental & physiological conditions of the plant
- The non-woody plant parts contains more than 70% of water by weight. In these regions metabolic activity is high
- Dry seeds contain about 5 – 10% of water. They are metabolically inactive. If water content is increased to normal level, dry seeds become active & grows
- Water molecule consists of two hydrogen atoms & one oxygen atom. They have covalent bonds to give special symmetry to water molecule. Due to this water possess special properties like higher boiling point & melting point, specific heat, high latent heat of vaporisation etc

<u>Importance of Water To Plants</u>:

1) In plant cells water acts as medium in which many biological reactions occurs
2) Water directly takes part in many metabolic activities such as photosynthesis, respiration, growth etc
3) Water plays an important role in photosynthesis. It is the source of electrons & protons which are involved in CO_2 fixation
4) Water is involved in hydrolysis of macromolecules & regulation of temperature in plants
5) Water controls the stomatal movement
6) Water is a medium for transport of materials
7) Water maintains the turgidity of plant cells
8) It is responsible for cell enlargement

The water content of plants will be in a continuous state of flux & depends upon

a) Level of metabolic activities

b) Water status of surrounding soil & air

- Absorption of water by plant cells, cell to cell, movement in different plant parts & its movement between plant & its environment constitute “plant water relations”.
- The concept of water potential is very important to study plant water relations

<u>WATER POTENTIAL</u>:

- Water moves on the basis of energy gradient. During this movement, free energy is liberated from water which is utilized to carry out various functions.

- Free energy is defined as "the amount of energy liberated from a substance when its potential energy is converted into kinetic energy".
- Free energy may also be defined as 'the energy available in a system for conversion into work'.
- "The amount of free energy present in one mole of a substance is called as chemical potential" (or) "Chemical potential of a substance is the free energy with which a substance react or move".
- Chemical potential indicates the ability of that substance to participate in different chemical reactions. It is represented by a Greek letter μ
- The term water potential was coined by R.O.Slatyer & S.A.Taylor (1960). They defined water potential of a system as "the difference between the chemical potential of water of that system".
- It is also defined as "the difference between the free energy of water molecules in pure water & the free energy of water molecules in a solution".
- Water potential is represented by a Greek letter ψ_w (i.e. P_{si}) & is measured in megapascals MPa.
- The water potential of pure water is zero (Stalyer & Tylor). In solution solute particles reduces the free energy & thus reduces water potential therefore water potential of a solution is always less than zero & negative
- Water moves from the region of higher water potential (less negative) to a region of lower water potential (more negative)

  Ex: Water potential of system A = - 2 bars
  Water potential of system B = - 8 bars
- Water moves from system A (ψ_w = - 2 bars) to system B (ψ_w = -8 bars). The movement of water molecules is continuous till water potential of both systems becomes equal
- In plant cells, water potential represents the algebraic sum of osmotic potential (ψ_π) & pressure potential (ψ_P) or wall pressure

  $\psi_w = \psi_\pi + \psi_P$
- Water potential can be expressed in atmosphere or bars (1 atmosphere = 1.01 bars; 1 bar = 0.981 atmospheres). Now it is expressed as Mega pascals (1MPa = 10bars)

<u>COMPONENTS OF WATER POTENTIAL</u>: Factors which contribute to water potential are called as components of water potential. The three factors are ---

a) Osmotic Potential
b) Pressure Potential
c) Matric Potential

a) <u>OSMOTIC POTENTIAL</u>: (π)

- The maximum hydrostatic potential applied to an aqueous solution to make its water potential equal to the water potential of pure water is called as osmotic potential (osmotic pressure)
- It may also be defined as "the quantum by which the water potential gets lowered on account of solutes is known as osmotic potential or solute potential.
- The value of osmotic potential is always negative & is represented by ψ_π (Psi, Pi). It is expressed in bars or megapascals
- The Osmotic potential of a solute depends upon the concentration of solution, ionisation of solute molecules, hydrophillic nature of solute molecules & temperature

b) <u>PRESSURE POTENTIAL</u>: (P or ψ_P)

- "The potential that develops in a system due to osmotic entry of water is called as pressure potential".
- It is represented by ψ_P & its value is always positive. It is expressed in bars or megapaseals

- Pressure potential may also be defined as "a positive hydrostatic pressure that develops in the cell due to osmotic entry of water".
- An equal of pressure is exerted by the cell wall on cell contents in opposite direction
- The pressure potential in plant cell is usually positive. In Xylem vessels the pressure potential is negative as water pulls the walls of vessels inwards.
  In plasmolysed cells, pressure potential is almost zero

c) MATRIC POTENTIAL: (ψ_m or T)

- The quantum by which the water potential gets lowered on account of matric forces (like hydrophillic colloids) is known as matric potential
- It is represented as ψ_m or T (Tau) & its value is always negative
- Dry colloids or hydrophillic surfaces such as wood, filter paper or gelatin has extremely negative matric potential (ex: 300 MPa)
- Water potential of a closed system can be expressed as ----
  $\psi = \pi + p + T$
  $(-) + (\underline{+}) + (-)$
- In living cells it is represented as ----
  $\psi = \pi + P$ (or) $\psi = \psi_\pi + \psi_P$

DIFFUSION:

- "The movement of ions or molecules of a substance from a region of higher concentration to a region of lower concentration is known as diffusion"
- Movement of ions takes place in all directions till equilibrium is attained
- Diffusion of one substance is independent of another substance in that medium
- Diffusion is driven by concentration gradient or potential gradient
- Diffusion of substances in air is more rapid that in water
- Diffusion helps in uptake & distribution of water, solutes & gases throughout the plant. It also helps in supply of CO_2 for photosynthesis & loss of water vapours from leaves during transpiration

IMBIBITION:

- "Adsorption of hydrophilic colloids like starch, proteins etc is known as as imbibition".
- The plant material, which shows imbibition are dry seeds before germination, any dry wooden piece etc
- Different types of organic substances have different imbibing capacities
  Ex: Protein – high imbibing capacity
  Starch – less imbibing capacity
  Cellulose – least imbibing capacity
- Therefore, proteinaceous pea seeds swells more than starchy wheat grains when soaked in water.
- Imbibition increases the volume of imbibiant due to which a kind of pressure develops which is known as imbibition pressure. It is of tremendous magnitude. Spitting of rocks in the crevices of rocks & soaking them in water

OSMOSIS:

- "Movement of water form a region of higher chemical potential to a region of lower chemical potential (lower concentration to higher concentration) through a selectively permeable membrane is known as Osmosis".
- It may also be defined as movement of solvent molecules from a lower concentrated solution to a higher concentrated solution through selectively permeable membrane
- Movement of particles accross the membrane occurs till equillibrium is attained

- Important driving force of osmosis is the free energy differences between two regions of water & water potential gradient between two systems
- Osmosis can be demonstrated by Osmometer or Osmoscope. (Thistle funnel experiment)
- At equilibrium met movement of water molecules between the two solutions is zero as water molecules diffuse in both directions in equal numbers
- The pressure exerted on higher concentrated solution to stop osmosis is known as osmotic pressure
- Osmosis helps in absorption of water, transport water within the plant, keeps the cells turgid, helps in stomatal movement, sleeping movement of leaves & opening of flowers

<u>PLASMOLYSIS</u>:

- When a cell is placed in hypertonic solution (higher concentrated solution) water comes out of the cell due to water potential gradient. The protoplast strinks away from the cell wall.
- "The shrinkage of protoplast of the cell due to exosmosis is known as plasmolysis". At this point, turgor pressure & wall pressure remain zero which can be represented by $\psi_w = \psi_\pi + 0$ or $\psi = \pi$
- When a cell is placed in hypotonic solution (lower concentrated solution) water enters into the cell (endosmosis) which results in an increase of protoplast volume & exerts a pressure against cell wall which is known as wall pressure.
- The pressure exerted by protoplast of turgid cell on the wall is known as turgor pressure Turgor pressure & wall pressure are equal but acts in opposite directions
- The condition of the cell where the cell shows first sign of plasmolysis is known as incipient plasmolysis. At incipient plasmolysis the protoplast does not exert any pressure against the cell wall. At this condition value of turgor pressure & wall pressure are zero. The water potential of the cell is equal to its osmotic potential.
  $\psi = \pi$
- In completely plasmolysed cell, the protoplast completely separates from the cell wall. The space between protoplast & cell wall is occupied by external solution
- If a plasmolysed cell is placed in water or hypotonic solution, water diffuses into the cell & the protoplast regains it original shape & size. This phenomenon is known as deplasmolysis
- Plasmolysis is a rare phenomenon. It takes place under extreme conditions of water stress or saline environment
- The pickles, jams & jellies may be spoiled by bacteria & fungal spores. Their growth can be prevented by adding salt to pickles & sugars to jams & jellies. The presence of salts & sugars cause the plasmolysis of bacteria & fungal spores. Which spoils the food stuffs

<u>ABSORPTION OF WATER</u>: The plants absorbs water through their roots. Water is mostly absorbed through root hair region

<u>Structure of root – hair</u>: Root hair is a tubular out growth of epidermal cells. It shows cell wall, cell membrane, thin layer of cytoplasm & large central vacuole

<u>Mechanism of Water Absorption</u>: Absorption of water takes place on the basis of water potential gradient. Water potential of soil solution is higher than the root hair due to which water enters into the root hair from soil. If water potential gradient increases, absorption of water also increases. This type of absorption of water is known as osmotic mechanism. Most of the water is absorbed through osmosis (Passive absorption)

Some plant physiologist reported that non-osmotic uptake of water also occurs in which ATP is utilized. This type of absorption of water is known as active absorption of water

ASCENT OF SAP

- "The upward movement of water through xylem against gravitational force from the underground absorbing root system to aerial transpiring shoot system is known as ascent of sap".
- The water that ascents upwards contains low concentration of mineral ions & hence the water is called as sap
- In herbs & shrubs, the distance between root tip & stem tip is some inches to some feet. In tall trees like Sequoia sempervirens (highest tree) & Eucalyptus sps. (highest tree among angiosperms) the distance between root tip & stem tip is more than 100 meters.
  In both the cases, water moves upward
- Malpighi (1672) & Stephen Hales (1727) carried out ringing experiment independently & showed that ascent of sap occurs through xylem
- Many theories were proposed to explain the mechanism of ascent of sap. They are categorised into ----
  1) Vital theories
  2) Root Pressure theory
  3) Physical theories

1) Vital Theories: According to these theories living cells are responsible for ascent of sap. Godlewski (1884), Janes (1884), J.C.Bose (1923) & Molish (1929) are proponent of vital theories.
  1) Goldewski proposed "relay pump theory".
  2) J.C.Bose proposed "pulsation theory".

2) Root Pressure Theory: Root pressure is "the positive hydrostatic pressure developed in the roots due to accumulation of absorbed water". The term root pressure was coined by Stephen Hales (1727). Root pressure is responsible for guttation & bleeding in plants.
  The role of root pressure in ascent of sap in all plants is uncertain. It is applicable to herbs, plants which transpire slowly & the plants growing in soil having sufficient amount of available water.

3) Physical Theories: According to these theories dead cells of xylem are responsible for ascent of sap. In plants like Sequoia, the distance between leaves & roots is about 120meters. In some case water has to be absorbed from a depth of 9 meters. Such a long distance pull of water can be explained by physical theories like
  - Cohesion- Tension theory, capillary theory & imbibition theory.
    a) Cohesion – Tension theory by Dixon & Jolly (1894)
    b) Capillary theory by Boehm (1809)
    c) Imbibition theory by Unger (1868)

Cohesion – Tension Theory:

- The most accepted physical theory is Cohesion-Tension which is proposed by Dixon & Jolly (1894)
- This theory is based on Cohesive & adhesive forces of water molecules, continuity of water column & transpiration pull
- **Cohesive Force** is the force of attraction between similar molecules. Water molecules are firmly attached to each other due to cohesive force. It is as high as 300 bars. Cohesive force prevents the breaking of water column even under high tension
- High surface tension & high cohesive force of water helps to maintain a continuous, unbroken water column in tracheary elements

- **Adhesive force** is the force of attraction between water molecules & walls of xylem vessels
- **Transpiration** pull is the force that develops in the leaves due to transpiration. It ranges from 20 –30 bars. It is sufficient to raise the water column to the tip of even the tallest trees

Mechanism of Ascent of Sap:

- Due to transpiration mesophyll cells lose water a result the water potential (ψ_w) of mesophyll cells decreases. Due to the decrease in water potential water moves into the mesophyll cells from adjacent cells. The adjacent cells in turn draws water from the xylem element of leaf. A tension develops in xylem elements
- The xylem of leaf is in continuity with xylem of stem & root, therefore tension is transmitted down to the root
- Due to upward tension i.e. transpiration pull water ascends up in the form of unbroken water column
- Due to cohesive force of attraction between water molecules, water column is not broken. Due to adhesive force between water molecules & walls of xylem vessels, water column is not broken or pulled away from their walls
- The cohesive force between water molecules & transpiration pull results in upward movement of water (Sap) from roots to mesophyll cells of leaves with respect to water potential gradient
  Cohesion – Tension theory can be demonstrated by an experiment called
  Sponge – Capillary tube experiment or porous pot experiment.

Evidence:

- A water potential of 10 – 20 atmospheres may develop in mesophyll cells during day time due to transpiration. This water potential is sufficient to raise water up to a height of 340 – 680 feet.
- The cohesive force between water molecules is found to be 20 – 300 atmospheres. This force is sufficient to prevent the breaking of water column

Objections Of Cohesion – Tension Theory: The objections of Dixon’s cohesion-tension theory are ----

2) The formation of gas bubbles in xylem i.e. cavitation may break up the water column. This is known as embolism. This objection is satisfactorily answered that whenever water column breaks up water takes a bypass (sideward course) & is pulled up
3) According to this theory tracheids are more efficient water conducting channels than vessels as cross walls of tracheids gives stability to water column. In the cource of evolution tracheids are replaced by vessels. This does not support the consideration of tracheids as efficient conducting channels

TRANSPIRATION

- “The loss of water in the form of vapours from aerial parts of the plant into external atmosphere is called as transpiration”. It takes place mostly through leaves
- Most of the water absorbed by the plant is lost through transpiration. Only a small fraction (1 – 5%) of water absorbed by the plant is utilized in various metabolic activities
- Wheat plant transpires 3000 litres of water for the production of one kilogram of grains. Corn plants transpire 40,450litres of water per day per on hectare

Evaporation & Transpiration:

- Evaporation is the loss of water in the form of vapours directly from water into the atmosphere

- Evaporation & transpiration are similar physical processes but there is a basic difference between evaporation & transpiration
- In evaporation environmental factors play an important role. In transpiration environmental & biotic factors plays important roles
- Evaporation is a physical process where as transpiration is a biological process involving process of evaporation
- Transpiration can be demonstrated by ‘Bell jar experiment’.
- The rate of transpiration is measured by “potometer”
- The rate & transpiration on both surfaces of leaf & also between leaves of different plants can be compared by “cobalt chloride experiment”

CONCEPT OF SOIL – PLANT ATMOSPHERE CONTINUM (SPAC):

- SPAC concept helps to understand the relationship between soil, plant & atmosphere
- Free movement of water exists between soil & plant, soil & atmosphere & plant & atmosphere
- Land plants acts as connecting system from soil to atmosphere through plants. This continuous system is known as SPAC
- Water moves in liquid from in the soil & with in plant body. Water moves by diffusion from plants into the atmosphere & also from soil to atmosphere in the form of vapours
- A gradient of water potential exists in SPAC. Water potential is maximum in the soil (-2 bars), minimum in the atmosphere (-1000 bars) & intermediate in plants (-10 to -30 bars)
- Water moves from a region of higher water potential to a region of low water potential. Hence a continuous movement of water from soil to atmosphere occur through plants. Transpiration plays a major role in this process. Thus SAPC is a biotic environmental water system. Transpiration is also a component of SPAC

TYPES OF TRANSPIRATION: Transpiration is classified into three different types---

1) Stomatal Transpiration
2) Cuticular Transpiration
3) Lenticular Transpiration

1) STOMATAL TRANSPIRATION: “Transpiration through stomata” is known as stomatal transpiration. Stomata are the small pores present on leaves. 90 – 95% of total transpiration occurs through stomata

2) CUTICUALR TRANSPIRATION: “Transpiration through cuticle” is known as cuticular transpiration. Cuticle is the thin layer present on the epidermis. 5 – 10% of total transpiration occurs through cuticle.

3) LENTICUALR TRANSPIRATION: “Transpiration through lenticles” is known as lenticular transpiration. Lenticles are the special apertures present on older stems of woody plants. About 1 – 2% of total transpiration occurs through tenticles

- Total transpiration that occurs through leaves is known as foliar transpiration. It includes stomatal transpiration & cuticular transpiration.

STRUCTUR OF STOMATA:

- Stomata are small apertures found in the epidermis of leaves & young stems. They cover 1 – 2% of leaf area.
- Stomata consists of a pair of guard cells Space present between guard cells is known as Stoma
- The wall of guard cells towards the aperture are thick & non-elastic where as outer walls are thick & elastic

- Cytoplasm of guard cell is in the form of thin periperal layer. It consists of large central vacuole, nucleus & other cell organells. Guard cells differs from epidermal cells in their shape & in presence of chloroplast
- Epidermal cells that surrounds the guard cells are known as subsidiary cells or accessory cells
- Stoma opensin an air cavity called sub-stomatal cavity
- Stoma along with guard cells & subsidiary cells constitue stomatal complex or stomatal apparatus
- In dicots guard cells are kidney shaped where as in monocots they are dumbell shaped
- In plants generally stomata do not close completely. They remain partially open to allow gaseous exchange

<u>DISTRIBUTION OF STOMATA</u>: The number of distribution of stomata per unit area of the leaf depends upon the type of plant & its habitat

a) <u>Apple & Mulberry Type</u>: <u>HYPOSTOMATOUS</u>: Stomata are present only on the lower surface of leaf. Ex: Apple, Mulbery, Peach, Walnut etc
b) <u>Potato Type</u>: AMPHISTOMATOUS: Stomata are present on both the surfaces of leaf. They are more on lower surface. Ex: Potato, Bean etc
c) <u>Oat Type</u>: Stomata are equally distributed on both surfaces of leaf.
 Ex: Maize, Oat, Grasses
d) <u>Water Lily Type</u>: <u>EPISTOMATOUS</u>: Stomata are present only on upper surface of leaf. This condition is generally seen in hydrophytes with floating leaves.
 Ex: Nymphae, Victoria, Nelumbium etc
e) <u>Potamogeton Type</u>: <u>ASTOMATOUS</u>: Stomata are either absent or if present they are non-functional. It is the characteristic feature of submerged hydrophytes.
 Ex: Hydrilla, Vallisneria, Potamogeton

<u>MECHANISM OF OPENING & CLOSING STOMATA</u>:

- The opening & closing of stomata are controlled by turgidity & flaccidity of guard cells
- When water enters into the guard cells from surrounding epidermal cells, guard cells becomes turgid. The outer walls of guard cells as a result stoma opens. When the guard cells lose water, they become faccid & stoma closes
- If water supply to the leaf is adequate & leaf temperature is moderate, light promotes opening & darkness promotes stomatal closure
- In most of the plants stomata open during day time & close at night. Such stomata are known as photoactive stomata
- In succulent plants like Bryophyllum. Stomata opens during night & close during day. Such stomata are known as scotoactive stomata
- Stomatal opening & closing are associated with metabolic changes & solute levels of guard cells. It is explained by K^+ pump hypothesis

<u>Opening of Stomata</u>:

- In the presence of light K^+ ions are actively pumped into the guard cells from the surrounding epidermal cells. ATP is generated from photophosphorylation or from respiratory breakdown of starch
- The uptake of K^+ ions is associated with active pumping of protons (H^+ ions) into the epidermal cells from guard cells. This pumping is carried out by membrane bound ATPase
- The entry of K^+ into the guard cells is associated with passive entry of Cl^- ions
- In the presence of light (day time), organic acids, mainly malic acid is produced from starch in guard cells
- Malic acid dissociates into H^+ ions & malate ions
- K^+ ions are transported into the guard cells & H^+ ions are transported into the epidermal cells

- Due to the presence of K^+, Cl^- & malate ions in guard cells water potential of guard cells become more negative. Water potential gradient develops between guard cells & surrounding epidermal cells & hence water diffuses from epidermal cells into the guard cells. The guard cells become fully turgid & stomata opens

Closing of Stomata:
- During dark K^+ ion pump & H^+ ion pump are switched off K^+ ions & Cl^- ions diffuses into surrounding epidermal cells from guard cells
- Some amount of malateions accumulated in guard cells are consumed in Kreb's cycle & remaining malateions diffuses into the surrounding epidermal cells
- As a result of all these events, water potential of guard cells becomes less negative hence water diffuses into the epidermal cells from guard cells. The guard cells becomes flaccid & stomata closes
- Stomata a sensitive to changes in p^H. High $p^H{}_{(7)}$ favours opening of stomata & low $p^H{}_{(5)}$ favours closing of stomata

FACTORS AFFECTING TRANSPIRATION: Several environmental factors and internal factors (plant factors) affects the rate of transpiration

I. Environmental Factors: (External Factors):
- The external factors which affects the rate of transpiration are light, temperature, wind velocity, humidity, atmospheric pressure & availability of soil water

1) Light: It directly controls the rate of transpiration. It controls stomatal movement, increases the temperature of leaf & permeability of cell membrane. An increase in light intensity increases the rate of transpiration
2) Temperature: Increase in temperature increases the rate of transpiration due to decrease in humidity. This affects on stomatal movements. Stomata close at very high temperature as well as at very low temperature
3) Humidity: The amount of water vapours present in the atmosphere is called as absolute humidity. The diffusion of water vapours from leaf to the atmosphere depends upon the vapour pressure of outside atmosphere. If humidity is less, the rate of transpiration is more. If humidity is more, rate of transpiration is low
4) Wind Velocity: Wind removes the water vapours in the surrounding atmosphere of the leaf & induces transpiration. Increase in the wind velocity, increases the transpiration rate. When a plant is suddenly exposed to wind, transpiration rate increases sharply & then decreases. Gentle breeze increases transpiration rate. High wind velocity increases transpiration rate which is followed by closure of stomata
5) Availability of Soil water: When sufficient amount of water is not available to plant, rate of transpiration decreases. Plants growing in dry soils shows poor stomatal opening due to faccidity of guard cells which results decrease in transpiration rate
6) Atmospheric Pressure: Rate of transpiration is inversely proportional to atmospheric pressure. Reduction in atmospheric pressure reduces the density of atmosphere as a result water vapours diffuses of atmosphere as a result water vapour diffuses rapidly from leaf into the atmosphere & transpiration rate increases. The plants growing at higher altitudes shows high rate of transpiration & shows Xerophytic adaptations

II. Plant Factors: (Internal Factors)
- Different plant factors which influences the rate of transpiration are root-shoot ratio, leaf area. Leaf structure, abscisic acid etc

1) Root –Shoot ratio: Rate of transpiration is influenced by the efficiency of absorbing system (roots) & evaporation system (shoot). The rate of transpiration increases with the increase in

root-root ratio. Root-shoot ratio is more in Sorgham than in Maize, therefore rate of transpiration is more Sorgham than in Maize

2) Leaf Area: There is no relation between rate of transpiration & leaf area. In large plants with broad leaves, the rate of transpiration per plant may be higher. The rate of transpiration per unit area is more in plants with smaller leaves than the plants with broader leaves. Rate of transpiration is influenced by stomatal frequency (number of stomata per unit area) and size of stomata

3) Leaf Structure: The structural modifications like reduced leaf surface, thick cuticle, waxy coating, multicellular epidermal hairs, multiple epidermis, multilayered palisade parenchyma, poorly developed spongy parenchyma, sunken stomata etc., reduce the rate of transpiration. These peculiarities are usually observed in xerophytes. If the detached mesophytic and xerophytic leaves are allowed to dry under ideal conditions, the mesophytic leaves wilt first. In xerophytes, the rate of cuticular transpiration is less and rate of stomatal transpiration is more than that of mesophytes

4) Abscisic acid (ABA): Under water-stress conditions, the quantity of abscisic acid increases in the guard cells. Abscisic acid promotes closure. As a result the rate of transpiration decreases

Significance of Transpiration:

- Some physiologists consider transpiration as a beneficial process. Some physiologists consider it as necessary evil (Curtis, 1926)

Advantages:

- The excess amount of water present in plant body is removed by transpiration
- Transpiration influences the absorption of water
- Transpiration helps in the distribution of water throughout the plant body
- Transpiration is the main force for ascent of sap
- Transpiration helps in absorption and transport of mineral ions
- Transpiration plays an indirect role in the distribution of organic food materials
- Transpiration gives a cooling effect and controls the temperature of plant body. Transpiration reduces leaf temperature

Disadvantages:

- Plants lose huge amounts of water due to transpiration. If rate of transpiration is high and sufficient water is not available, cells face water shortage and physiological processes are slowed down
- Under water shortage conditions plants wilt and dry up, due to transpiration. This is the reason for shedding of leaves by deciduous trees to avoid transpiration during summer.

Anti-transpirants:

- These substances reduce the rate of transpiration. Phenyl mercuric acetate (PMA), Abscisic acid (ABA) are the common anti-transpirants. Phenyl mercuric acetate causes partial closure of stomata
- Colourless plastics, polyethylenes etc., are also used as surface films on leaves to reduce transpiration. CO_2 at high concentration also brings about stomatal closure. A dilute suspension of chalk powder prevents transpiration

Guttation:

- The loss of water in the form of drops from the edges of leaves is called guttation (a term coined by **Burgerstein**). It takes place through special structures called hydathodes or water stomata. Hydathode is a stoma- like pore present at the tip of margin of the leaf. It consists of a pore in the epidermis.

- It is surrounded by permanently opened guard cells. Below the pore loosely arranged parenchyma cells are present. These cells constitute epithem. Epithem lies above a vein ending
- Guttation is observed in herbaceous plants growing in moist and warm soils. Guttation is reported from 333 genera belonging to 115 families. It can be best observed in *tomato*, *grasses*, *Colacasia*, *Tropaeolum* etc. Species of *Saxifraga* guttate actively during flowering. *Colacasia antiquoram* loses 10 to 100 ml of water per day through guttation
- Guttated water contains several dissolved mineral ions, enzymes, amino acids, vitamins, sugars etc. Guttation takes place during warm humid nights. The cause of guttation is mainly root pressure.

MINERAL NUTRITION

- For normal growth & development, all living organisms require carbohydrate, proteins, fats & minerals
- Green plants can prepare their food from simple inorganic substances (like water & CO_2) by the process of photosynthesis.
- In the formation of carbohydrates, proteins & fats, carbon, hydrogen & oxygen plays an important role.
- In addition to these three elements, plants needs other elements also for their survival
- Plants absorb inorganic substances from the soil generally in the form of ions through their roots
- Inorganic substances are mainly mineral in origin & hence "the absorption of & utilization of inorganic substances is known as mineral nutrition".
- Aristotle proposed that plants absorb nutrients in the form of organic substances from soil (Humus Theory).
- Jan Baptista van Helmont (1667) reported that 'rain water provide food to the plants'
- John Woodward (1699) proved that not only water but also materials dissolved in it also plays an important role for growth of plant.
- He conducted experiments on 'Spearmint plant' which were grown in rain water, water from Thames river & water to which garden soil is added
- He observed that plants survived only for some time in rain water, grow better in river water & showed best growth in water added with garden soil. Thus he established that soil is essential for growth
- de Saussure (1804) reported that plants grew better in salt solution
- Present day knowledge of mineral nutrition is mainly due to 'water culture experiments of Julius Sachs & W.Knops
- Technique of growing plants in water solution containing inorganic salts, without soil or organic matter is known as Hydroponics

<u>Criteria Of Essentiality</u>: Ash analysis of plants reveals that there are about 60 elements in plants

- All these elements are not common in all plants as they are not necessary for normal growth
- Arnon & Stout (1939) proposed three criteria to determine the essentiality of elements ----

1) The element should be necessary for normal growth & reproduction of plant
2) Element should be involved directly in metabolism
3) The element must be specific & can't be substituted by any other element

- On the basis of Arnon's Criteria of essentiality, 16 elements are found to be essential. These elements are known as essential elements

- The essential elements are Carbon, Hydrogen, Oxygen, Nitrogen, Phosphorous, Potassium, Calcium, Magnesium, Suphur, Iron, Manganese, Zinc, Copper, Boron, Molybdenum & Chlorine
- The other elements which are present in the plants are known as non-essential elements
- Among 16 essential elements, nine elements are required by the plants in large quantity & are known as macro-elements or major elements or macronutrients
- The major elements are C, H, O, N, P, K, Ca, Mg & S
- Remaining seven elements are required by the plants in small quantity & hence known as minor elements, micronutrients or trace elements
- Minor elements are Fe, Mn, Zn, Cu, B, Mo & C*l*
- According to recent studies Nickel is also considered as important micro elements
- Sodium is required by C_4 plants & is considered as 17^{th} essential elements

S.No.	Essential Element	Symbol	Available form
1.	Hydrogen	H	H_2O
2.	Oxygen	O	O_2
3.	Carbon	C	CO_2
4.	Nitrogen	N	NO_3^-, NH_4^+
5.	Potassium	K	K^+
6.	Phosphorous	P	$H_2PO_4^-$, HPO_4^{-2}
7.	Calcium	Ca	Ca^{+2}
8.	Magnesium	Mg	Mg^{+2}
9.	Sulphur	S	SO_4^{-2}
10.	Iron	Fe	Fe^{+2}, Fe^{+3}
11.	Manganese	Mn	Mn^{+2}
12.	Boron	B	BO_3^{-3}
13.	Zinc	Zn	Zn^{+2}
14.	Copper	Cu	Cu^{+2}
15.	Molybdenum	Mo	MoO_4^{-2}
16.	Chlorine	C*l*	Cl^-

Role of Mineral Nutrients & their deficiency:
Symptoms:
1) CARBON:
- It is absorbed by plants is the form of CO_2 from air or as bicarbonates from water
- It is essential components of all organic compounds
- 45% of dry weight of plants is due to carbon hence it is the chief constituent of dry weight of plant body
- Dry weight of plant body increase during photosynthesis & decreases during respiration

2) HYDROGEN:
- It is absorbed by plants in the form of water
- It is also the structural element of all the organic compounds
- It plays an important role in redox reactions
- At the end of respiration, it oxidises to form metabolic water

3) OXYGEN:
- It is absorbed in the form of O_2 gas from air & water
- It is the structural element of all organic compounds

- It is the main constituent in the fresh weight of plants (43%)

Note: Plants can not survive without these three elements therefore deficiency symptoms are not shown by plants

- Carbon, Hydrogen & Oxygen are therefore known as structural elements or frame work elements

4) NITROGEN: It is 2nd most important element for plants next to carbon

- It is the structural component of many organic compounds
  Ex: Proteins, nucleic acids, enzymes co-enzymes, chlorophyll etc
- Plants can not utilize gaseous nitrogen (N_2) from the atmosphere
- They can utilize nitrogenous compounds like NO_3^-, NH_4^+, Urea, Amino acids
- Soil is generally deficient in Nitrogen due to excessive assimilation of Nitrogen by crop plants & improper functioning of soil biological system. Deficiency can be overcomed by using green manure or nitrogenous fertilizers

Role & Deficiency Symptoms of Essential Elements:

Element	Obtained as	Role	Deficiency Symptoms
1) Nitrogen (mobile element)	NO_3^-, NH_4^+	• structural component of many organic compounds Ex: Proteins nucleic acids, enzymes	• Chlorosin first appears on older leaves & later on younger leaves • Purple coloured spots develops on plant parts due to anthocyanin pigment • Flowering is delayed • Promotes vegetative growth
2) Phosphorous (mobile element)	HPO_4^{-2}, $H_2PO_4^-$	• Structural component of nucleic acids, NADP & ATP • acts as activator of some enzymes • required in protein synthesis & formation of cell wall	• Chlorosis first appear on older leaves • Stunted growth • Leaves become dark green • Plant parts become purple coloured due to anthocyanin pigment • Dead necrotic spots on leaves • Promote leaf fall & delay flowering
3) Potassium (mobile element)	K^+ ions	• Activator of many enzymes • Plays important role in respiration photosynthesis & protein synthesis • regulates stomatal movement • maintains ionic equilibrium in cells	• Mottled chlorosis in the middle of leaves • Necrotic spots appears at the tip & margin of leaves • Lodging of plants • Plants become bushy due to decrease in apical dominance • Plants shows stunted

			growth
4) Magnesium	Mg^{+2}	• Central atom of chlorophyll • Stabilises ribosomes • Activator for many enzymes of photosynthesis & respiration	• Interveinal chlorosis of older leaves • Appearance of bright coloured pigment • Necrosis of older leaves in acute shortage
5) Calcium	Ca^{+2}	• Constituent of middle lamella • Involved in the formation of nucleus & mitochondria • Activator of enzymes like amylase	• Formation of multinucleate cells • Chlorosis along the margin of young leaves • Formation of stunted & discoloured roots
6) Sulphur	SO_4^{-2}	• Constituent of aminoacids cystein & methionine • Constituent of vitamins like biotin, thiamine & Co-enzymes	• Chlorosis of younger leaves • Stunted growth & delayed flowering • Root system become extensive & stem becomes woody
7) Iron	Fe^{+2}, Fe^{+3}	• Constituent of electron carriers Ex: ferridoxin, cytochrome • Essential for chlorophyll synthesis • Activator for oxidising enzymes	• Interveinal chlorosis of younger leave • Necrosis may follow
8) Maganese	Mn^{+2}	• Activator for enzymes of photosynthesis & respiration • necessary for photolysis of water	• Interveinal chlorosis of younger or older leaves followed by necrosis • Disorganisation of thylakoids in chloroplasts
9) Zinc	Zn^{+2}	• Involved in auxin synthesis • Activator for more than 80 enzymes • Essential for synthesis of tryplophan	• Interveinal chlorosis of older leaves followed by necrosis • Little leaf & rosette in same plants • Shortening of internodes • Mottled leaf disease in many fruit plants Ex: Apple, Citrus etc
10) Copper	Cu^{+2}, CU^{+3}	• Constituent of plastocyanin, plastoquinone	• Young leaves become twisted & dark green coloured

		• Activator for oxidising enzymes • essential for synthesis of ascrobic acid	• Reclamation disease (yellow tip) in cereals & legumes • Exanthema in fruit trees die back in Citrus
11) Molybdenum	MoO_2^{-2}	• Constituent of nitrate reductase • Essential for nitrogen fixation & Phosphorous metabolism	• Whip tail in crucifers • Interveinal chlorosis of order leaves followed by necrosis • Young leaves become twisted
12) Boron	$H_3BO_3^-$	• Involved in translocation of sugars • Essential for DNA synthesis • Acts as natural inhibitor • Promotes elongation of pollen tube	• Apical regions of stem dies • Leaves become thick & dark coloured • Flowering is suppressed • Heart rot of beet, water core of turnip
13) Chlorine	Cl^-	• Stimulate spletting of water during photosynthesis • Essential for growth of roots & for division of leaf cells	• Leaves become wilted • Leaves may show chlorsis & necrosis • Roots become thick & slunted

ABSORPTION OF IONS

Mineral salts exists in dissolved state in soil water. Salts dissociate in cation & anions in soil water. “Plants absorb mineral ions from the soil which is known as ionic absorbtion”.

- Ions may be bound to the soil particle or may occur free in soil solution
- Some of the scientiest who studied Ion absorption are Hoagland , Knops, Epstein, Pfeffer, Lundegard & Steward etc
- Absorption of ions of two types -----

i) Passive Absorption ii) Active Absorption

i) PASSIVE ABSORPTION: “Absorption of ions according to concentraion gradient without using metabolic energy is known as passive absorption.

- It is also known as passive absorption
- Main theories of passive absorption are ----
  a) Donnan equilibrium
  b) Ion exchange hypothesis
  c) Mass flow or Bulk flow

Donnan’s Equilibrium: It was proposed by F.G.Donnan (1911). “Entry of ions into the cell across the cell membrane to maintain an electrochemical equilibrium is known as Donnan Equilibrium”.

Ion-Exchange Theory: It was proposed by Jenny & Overstreet (1938). “Exchange of ions with similarly charged ions of soil solution is known as ion exchange”.

- It is of two types ---

a) Contact exchange theory b) Carbonic acid exchange theory

Contact exchange-theory: Exchange of H^+ ions & OH^- ions of the root with similar charged ions absorbed. When they contact each other is known as contact exchange

Carbonic acid exchange theory:

- CO_2 liberated by roots dissolve in soil water & forms carbonic acid (H_2CO_3). It dissociate into H^+ & HCO_3^- ions.
- "Exchange of H^+ & HCO_3^- ions with similar charged ions of soil solution is called carbonic acid exchange theory".

Bulk Flow or Mass flow: It was proposed by Kramer (1956)

- "Movement of ions into the root along with stream of water under the influence of transpiration of is called mass flow or bulk flow".

ACTIVE ABSORPTION: "Absorption of ions against concentration gradient by utilizing metabolic energy is known as active absorption of ions".

- It results more ion concentration in plants than in external soil solution.
- Hoagland observed that in Nitella & Valonia K^+ ions accumulation 200 – 1000 time more than surrounding medium
- Increase in the rate of respiration is followed by increase in the rate of salt absorption which is known as salt respiration or anion respiration.
- Rate of ion accumulation depends upon the metabolic rate
- Metabolic inhibitors like azides & cyanides inhibits the process of respiration hence ATP is not generated as a result ion accumulation is also inhibited
- Special type of proteins present in cell membrane fecilitate the uptake of ions across the membrane. These proteins are known as carrier proteins
- The carrier proteins show high degree of specificity to the substance (i.e. ions)
- Recent studies showed that carrier proteins fecilitate active transport of ions from outer space (soil solution) to inner space (into cell)
- Carrier proteins are of two types
  i) Uniporter ii) Co-porters
- Transport of an ion from outside to inside by some carriers is known as uniport & such carriers are known as uniporters.
  Ex: H^+ AT Pase, Na^+ AT Pase
- Transport of an ion is coupled with other ion is known as co-transport
- Co-transport is of two type
  a) Symport b) Antiport

Symport: "Transport of two types of ions in the same direction is known as symport". The carriers are known as symporters. Ex: Movement of H+ ions is coupled with either NO_3^- or Cl^- or PO_4^-

Antiport: "Transport of two types of ions in opposite direction is known as antiport". The carriers are known as antiperters. Ex: inward movement of H^+ ions is associated with outward movement of Na^+ ions

- In transport mediated by carrier proteins, ions being transported is initially bounded to specific site of carrier protein. Binding cause confirmational change in the protein which exposes the ions to the other side of the membrane & ions are released from the binding site of protein
- Various steps are involved in active transport of ions in plants mediated by H^+ AT Pase pump. The steps are ----

i) Primary Active Transport:

- Pumping out of protons (i.e. H^+ ions) alone from cytosol (symplast) to outside by H^+ AT Pase pump (apoplast) is known as primary active transport. ATP hydrolysis provides the required energy
- Due to pumping of protons, proton concentration gradient is established across the membrane. (i.e. more protons are outside than cytosol).

ii) Secondary Active Transport:

- Proton concentration gradient results flow back of protons into cytosol is associated with co-transport of other ions against their own concentration gradient is known as secondary active transport

HYDROPONICS: (Solution Culture)

- Growing of plants in balanced nutrient solution in the absence of soil is known as hydroponics
- In this method, plants are grown in large shallow pots containing nutrient solution. The pots are covered with wire netting to provide support to the plants. Aeration is provided with the help of an inlet tube. Plants are also grown on a network of pipes in which nutrient solution runs continuously

Advantages:

- Desirable nutrients can be supplied to the crop plants
- P^H can be regulated at frequent intervals
- Tillering & weeding etc are not required
- Growth of crop will be uniform

Disadvantages:

- It is suitable only for some specific & valued crops
- Technical skills are required by farmers. In USA, Japan & Israel crops like radish, tomato, lettuce & cucumber are commercially grown by this method.
- Instead of supplying nutrient solution, moist air laden with nutrient is also supplied to the roots. Such technique is known as aerophonics.

BIO – INDICATORS: Some plants indicates the presence of specific metal deposits present in soil. Such plants are known as mineral indicators or bioindicators. They grow in mineral rich soils by developing metal tolerance

Ex: Agrostis tenuis grows on lead mines

- Astragalus & Haplopappus grows in selinum rich soils
- Impatiens balsamina grows near Zinc mines
- Gysophila patrini grows in Copper rich soil
- Polycarbia synandra Var gracilis grows near lead deposits
- Secondary transport involves binding of ions to the specific carrier protein followed by confirmational change in the protein & finally release of ions to the other side of the membrane
- Secondary transport involves either symport of ions (Cl^-, NO_3^-, HPO_4^-) or antiport of ions (Na^+ is transported out)
- Thus H^+ ions circulated across the membrane to the outer side through primary active transport of other ions) through secondary transport. For the primary transport of ions (H^+ ions) ATP directly provides the energy. Proton motive force drive the secondary transport

PHOTOSYNTEHSIS

- Synthesis of carbohydrates by green plants by utilizing water and carbon in the prescience of Sunlight is called photosynthesis
- Scientist proposed that green plants purify air only in the presence of Sunlight
- It is an anabolic or constructive process. It supplies food, energy and Oxygen for all organisms
- Amount of Oxygen liberated during photosynthesis for synthesis of 180gms. Of glucose is 192gms
- Most important feature of photosynthesis is conversion of light energy into chemical energy
- Cell organelle concerned with photosynthesis is chloroplast. Grana of chloroplast are useful for light phase and stroma for dark phase
- A attack of thalykoids is called Granum
- The chief photosynthesis pigment is chlorophyll. It shows porphyrin structure and contains Mg atom in the center of its head
- Metallic atom useful for attachment of four pyrrole rings in chlorophyll molecule is Magnesium
- Phytol is chlorophyll molecule is made up of a chain of carbon atoms
- Chlorophyll were classified into nine types of Aronoff & Allen
- Molecular formula of chlorophyll a is $C_{55}H_{70}O_5N_4Mg$
- Molecular formula of chlorophyll b is $C_{55}H_{70}O_6N_4Mg$
- The light absorbing portion of a pigment is called chromophore
- Accessory pigments (carotenoids and phycobilius) absorb light transmit it to chlorophyll
- Photo-oxidation of chlorophyll in high intensity is called solarization
- Photosynthetic unit is called quantasome. It is a group of pigment molecules, enzymes, photon or quantum
- Red and blue are the main colours of light absorbed by chlorophylls. These two colour most effective for photosynthesis
- Rate of photosynthesis is maximum in red light
- Graph showing absorption of light at different wave lengths is called absorption spectrum.
- A graph showing photosynthetic yield at different lengths of light is called action spectrum
- First reaction taking place during photosynthesis is excitation of chlorophyll molecule by absorption of light
- Liberation of 0_2 m photosynthetic higher plants was proposed by Van Niel
- Splitting up of water and liberation of oxygen by illuminated chloroplasts in the presence of Hydrogen acceptor is called Hill reaction or photolysis of water
- Quinone and ferric compounds used by Robert Hill in his experiment are called Hill oxidants (Hill conducted the experiment with the chloroplast of Stellaria media)
- Ruben & Kamen proved experimentally that O_2 is liberated from H_2O. They used ^{18}O in their experiment
- Photosynthesis yield increases when far red light is supplied along with red light of short wave it is called Emerson's enhancement effect
- Emerson proposed the presence of two pigment systems (PSI & PS II) participating simultaneously in light phase
- PSI of chlorophyll a in its reaction centre called P_{700}. PS-II consists of P_{580} in its reaction
- Photophosphorylation discovered by Arnon. Synthesis of ATP in the chloroplast by utilizing Sun light called Photophosphorylation

- Scientist who demonstrated synthesis of ATP by illuminated Chloroplasts is Arnon
- In cyclic Photophosphorylation, electrons return to the same chlorophyll. 2 ATP are synthesized for a pair of electrons
- During non-cyclic Photosphorylation, electron loss is PSI is compensated by the electrons from PS II
- Ultimate electron donor during non-cyclic Photophosphorylation is Water
- Non-cyclic Photophosphorylation is associated with photolysis of water. PSI & PSII participates NADPH + H and 1/2 O_2 are formed for transfer of a pair of electrons
- Number of quantum required for liberation of a molecule of oxygen during photosynthesis is Eight. This is called quantum requirement
- ATP & NADPH + H^+ required for reduction of a molecule of CO_2 during dark phase is 3ATP and 2 NADPH + H^+. It is called one unit of assimilatory power
- To reduce $6CO_2$ to $C_6H_{12}O_6$, 18ATP and 12NADPH + H are utilized
- During dark phase, assimilatory power is utilized to reduce CO_2 to
- Radio active substance is used in tracing Calvin cycle is C_{14}
- Product formed due to carboxylation during Calvin cycle is PGA
- Substance formed due to reduction in Calvin cycle is PGAL
- Proportion of triose phosphate utilized for regeneration of RuBP during Calvin cycle is $5/6^{th}$
- Plants showing calving cycle are called C_3 plants. RuBP is the acceptor of CO_2 and PGA the first stable product in these plants
- In some tropical grasses and few dicots; CO_2 reduction takes place through Hatch – Slack cycle. Such plants are called C_4 plants
- In C_4 plants PEP is the acceptor of CO_2 and OAA is the first stable product
- C_4 plants shows *Kranz* anatomy in their leaves. Bundle sheath cells. Carry out Calvin cyclic and mesophyll cells carry out Hatch –Slack cycle in these plants
- CO_2 liberated from malic acid in C_4 plants is accepted by RuBP of bundle sheath cells
- In Succulents fixation of CO_2 takes place during night. Organic acids accumulate in the night and oxylated in light. Such mechanism is called CAM pahtway
- Law of limiting factors was proposed by Blackman. CO_2 and light are common limiting factors for photosynthesis
- Intensity of light at which rate of photosynthesis equals rate of respiration is called compensation point
- Rate of photosynthesis is high in intermittent light compared to continuous light
- Decrease in rate of photosynthesis in high conc of oxygen is called warburg effect
- Experimental organism used by Calvin chlorella
- Experiment used to prove liberation of O_2 during photosynthesis is Hydrilla Photosynthesis
- Absorption of oxygen during photosynthesis is proved by Moll’s half leaf experiment
- Necessity of light for photosynthesis is proved by Light screen experiment
- If $C_{18}O_2$ is used in photosynthesis, the products labelled are Carbohydrates and water
- DCMU is Dichlorphenyl dimethyle urea, It is herbicide. It inhibits oxygen release reaction of light phase
- In C_3 plants, more CO_2 is released in the light than in the dark. This is due to Photorespiration
- The cell organelles concerned with photorespiration are Chloroplast Peroxisomes and Mitochondria
- Photosynthesis is an important Physico-biochemical process of the universe
- It is an anabolic and endergonic process
- In Photosynthesis light energy is photochemically used to reduce CO_2 to carbohydrates

- Oxygen is the by-product in this process (Except in bacterial Photosynthesis)
- The overall equation of photosynthesis is represented as
  $CO_2 + 12H_2O \xrightarrow[\text{chlorophylls}]{\text{light}} C_6H_{12}O_6 + 6H_2O + 6O_2\uparrow$
- Carbohydrates are the primary products of photosynthesis. These are metabolished to lipids, nucleic acids proteins etc.
- Total amount of radiant energy used by green plants is only 1%
- Every year two billion tons ($2x10^9$) of CO_2 is fixed by green plants globally
- 90% of the world photosynthesis is performed by algae

Photosynthetic Pigments:

- Chloroplasts, possess all the photosynthetic pigments
- It is one of the largest cell organelles of a mesophyll cell
- The chloroplast is surrounded by double differentially permeable membranes, with a periplastidial space
- The matrix of the chloroplast is called stroma
- Stroma contains the enzymes concerned with dark reaction of photosynthesis
- Thylakoids are embedded in the stroma
- The stacks of thylakoids are called grana (single granum)
- The region where one granum is in contact with the other is called **Appressed** region
- Grana are linked by fret membrane or stroma lamellae
- The cavity of the thylakoids is called lumen
- The photosystems (PS-I & PS-II) or photosynthesis units are present in the thylakoid membrane
- Each photosystem has two components
- They are Antenna chlorophyll complex or light harvesting complex (LHC) and Reaction centre
- Antenna chlorophyll complex has several hundred chlorophyll molecules and other pigments bound to proteins (LHC of PS-I has 200 chlorophyll a and b molecules in the ratio 3:1 while LHC of PS-II has 250 chlorophyll a and b molecules in the ratio of 1:1)
- The antenna absorbs radiant energy and supply to the reaction centre
- Reaction centre is the chlorophyll ‘a’ molecule which converts the light energy into chemical energy
- The reaction centre in PS-I is P_{700} (absorption maximum at 700 nm) while for PS-II it is P_{680}
- Pigments present in the chloroplasts are chlorophylls, carotenoids and phycobilins
- Chlorophylls harvest light energy
- Structurally the chlorophyll consists of two parts namely, a porphyrin (tetra pyrorollic head) and a phytol tail
- Porphyrin head consists of four pyrrole rings arranged in a cyclic manner
- A magnesium atom is present in the centre of the porphyrin. The four pyrole rings are attached to this central magnesium atom
- Phytol is a chain of 20 carbon alcohol and is esterfied to the fourth pyrrole ring of porphyrin head
- Five types of chlorophylls are known. They are chlorophyll – a, b, c, d & e
- Chlorophyll a (green colour) is present in all photosynthesis organisms (except photosynthesis bacteria)
- Chlorophyll b (olive green colour) is found in higher plants & green algae (Chlorophyceae)

- Chlorophyll c is found in brown algae (Phaeophyceae) and diatoms (Bacillario phyceae)
- Chlorophyll d is present in Red algae (Rhodophyceae)
- Chlorophyll e is present in yellow algae (Xanthophycae)
- Chlorophyll c, d & e exclusively present in algae
- In chlorophyll a methyl group is attached to 3^{rd} carbon in the porphyrin head while in chlorophyll b, an aldehyde is attached in the same position
- Carotenoids are accessary pigments
- They belong to a group of compounds called terpenoids
- They are yellow, orange – purple pigments
- Unlike chlorophyll, they are open chain compounds
- They are of two types namely cerotenes (hydrocarbons – $C_{40}H_{56}$) and xanthophylls (oxygenated hydrocarbons $C_{40}H_{56}O_2$)
- Lycopene, α - carotene and β - careotene are common carotenes
- Lutein and zeaxanthin are common xanthphylls
- Carotenoids perform dual function
  a) They trap the radiant energy 8 transfer to chlorophyll a (reaction centre)
  b) They prevent the chlorophyll from photobleaching (photo oxidation)
- Phycobilins are exclusively present in algae only (i.e, red and blue green algae)
- These are water soluble
- They resemble chlorophyll but they are devoid of central magnesium atom. Thus the four pyrrole rings are arranged in linear manner
- Phycobilins are of two types:
  a) Phycoerythrin – Red colour b) Phycocyanin – Blue colour
- The radiant energy trapped by the carotenoids and phycobilins (accessary pigments) cannot be directly used in Photosynthesis
- The radiant energy trapped by all the photosynthetic pigments in the antenna is finally transferred to the reaction centre of the photosystem
- This phenomenon is called **inductive** resonance of resonance transfer
- 95 to 99% of the photons absorbed by the antenna pigments have their energy transferred to the reaction centre
- A graph showing the absorption of light by pigments at different wavelengths of light is called absorption spectrum. This is prepared by Spectrophotometer
- A graph showing the rate of photosynthesis at different wavelengths of light is called action spectrum
- The source of energy for photosynthesis is light
- Spectrum of light comprises visible & invisible parts
- Effective light in photosynthesis is only visible light (which has seven colours – VIBGYOR)
- Wavelength of visible light ranges from 390 nm to 760 nm. This called photosynthetically active radiation – PAR
- Light has both wave and particulate nature
- The particulate nature of light is expressed as photons or quanta
- Energy of photon is inversely proportional to the wavelength
- Photons of blue light are more energetic than those of red light
- Chlorophyll a absorbs a photon of light and gets excited (Chl*) $Chl + h\nu \rightarrow Chl^*$
- The chlorophyll remains in an excited state for a time of 10^{-9} seconds
- This excitation energy is used in photosynthesis

Mechanism of Photosynthesis

- Photosynthesis consists of two phases, namely, light phase and dark phase (According to F.F Blackman 1905)
- Light phase occurs in grana
- It involves the production of ATP & NADPH $+H^+$ from radiant energy (Assimilatory power)
- Dark reaction occurs in the stroma of the chloroplast. Assimilatory power is utilized for the reduction of CO_2 to carbohydrates

Light Reaction

- Light reaction includes
  a) Hills reaction
  b) Emerson enchancement effect
  c) PS-I & PS-II – Photosynthetic electron transport and proton translocation
  d) Photophosphorylation – ATP production
- Hill's reaction – Isolated chloroplasts would release O_2 in presence of sun light and a suitable oxidising agent (hydrogen acceptor). This is called Hill reaction (demonstrated by Robert Hill 1937)
- The hydrogen acceptor is potassium ferric oxalate
  $2H_2O + 2A \xrightarrow[\text{chloroplast}]{hv} 2AH_2 + O_2$

  A = Hill reagent
- Hill's reaction is significant in the sense that it demonstrates the role of water as a reducing agent in photosynthesis
- It is clear that the source of O_2 in photosynthesis is water, but not CO_2
- Ruben & Kamen (1941) have shown that water is the source of O_2 by using isotope ^{18}O of oxygen
- In case of bacterial photosynthesis, hydrogen donor is H_2S
  $2H_2S + CO_2 \rightarrow CH_2O + H_2O + 2S\downarrow$
  Note: O_2 is not evolved in bacterial photosynthesis
- In higher plants photosynthesis hydrogen donor is water
  $2H_2O + CO_2 \rightarrow CH_2O + H_2O + O_2\uparrow$

Emerson Enhancement Effect

- Robert Emerson studied the quantum yield of photosynthesis in Chlorella (a unicellular green alga)
- Emerson discovered that in this alga the red light of wavelength longer than 680 nm lowers the rate of photosynthesis. This is called **red drop**
- Later Emerson et al observed that when a beam of shorter wavelength (650 to 680 nm) and longer wavelength (>680 nm) are used simultaneously, the photosynthesis is higher than the sum of the two rates with separate beams. This phenomenon is called Emerson enhancement effect
- Emerson enhancement effect suggests that photosynthesis involves two pigment systems (now called photosystems – I and II)
- These systems operate simultaneously in series for the photosynthetic electron transport and proton translocation

PS –I and PS –II Photosynthetic electron transport & Proton translocation

- The PS-I and PS-II which operate in series are linked by a third multiprotein complex called as cytochrome complex All these complexes are present in thylakoid membrane
- Thus the chain of three complexes will extract low energy electrons from water and along with the solar energy (hν) trapped by PS-I and PS-II, the energy levels of electrons are raised finally to produce NADPH + H^+

  The various steps in electron transport mechanism are
- Step –I: Absorption of sunlight (<680 nm) by PS-II and excitation of the reaction center (P_{680}*) occurs
- Step –II: Electrons from reaction of PS-II (P_{680}*) are conveyed to pheophytin. (A special magnesium atom is replaced by two hydrogens). The reaction center of PS-II is now oxidised (P_{680}*) due to loss of electrons
- Step –III: The oxygen evolving complex (OEC) supplies electrons for the reduction of (P_{680}^+). OEC consists of a few proteins four Mn^{2+}, Ca^{2+} and Cl^- ions associated with PS-II. OEC is responsible for photolysis of water. The splitting of water in the presence of light and the consequent evolution of O_2 is known as photolysis of water

  $H_2O \xrightarrow{h\nu} \frac{1}{2}O_2 + 2H^+ + 2e^-$

  This O_2 is the main source of atmospheric oxygen.

  The above two protons are released into the lumen of the thylakoid
- Step IV: Electrons from pheophytin enter in to a quinone cycle of (Q-cycle) in which a plastosemiquione (PQ) is reduced to form plastoquionol (PQH_2) by drawing one electron from PS-II and two protons ($2H^+$) from the stroma

  PQH2 is oxidised to PQ by donating electron to cytochrome b/f complex. The protons are released into the lumen of the thylakoid

Note: For every two electrons passing from PS-II to cytochrome b_6 and cytochrome f complex, quinone cycle facilitates the transfer of four protons ($4H^+$) into the lumen of the thylakoid

- Step V: Electron from cytochrome complex are conveyed to plastocyanin, a copper containing protein. This protein is called as a mobile carrier as it has the ability to move freely along the lumen side of the thylakoid membrane
- Step VI: After absorbing longer wavelength of light, PS-I gets excited (P_{700}*). The excited P_{700}* passes the electrons to a primary electron acceptor (unknown). From there the electrons are passed to ferredoxin (Fd). Fd is an iron sulphur protein present in the stroma side of thylakoid.
- Step VII: The excited P_{700}* is oxidised (P_{700}^+). The electron deficiency to P_{700}^+ is compensated by PC.
- Step VIII: The reduced Fd transfers the electrons to $NADP^+$ and reduces it to NADPH+H^+ in presence of the enzyme Fd-NADP oxido reductase
- The flow of electrons during non cyclic transport from PS-II to PS-I is inhibited by DCMU (Dichloro methyl dimithyl urea)
- The non cyclic electron transport is referred to as Z- scheme
- Each pair of electrons passing through the non cyclic electron transport contributes 6 protons to the lumen of the thylakoid (Four from Q cycle and two from water oxidation)
- ATP synthesis occurs from high energy protons

Photophosphorylation

- The process of Photophorylation was first described by D.Arnon
- Light driven production of ATP by the chloroplasts is known as photophosphorylation

- Formation of ATP in associated with non cyclic electron transport (PS-I and PS-II) is called as non cyclic photophosphorylation
- ATP formation in thylakoids is explained on the basis of Chemiosmotic theory as proposed by Peter Mitchel (1961) According to this theory, p^H gradient on either side of thylakoid membrane is responsible for ATP formation
- CF_0 acts as a proton channel where as CF1 is the catalytic site which synthesizes the ATP
- Thus photophosphorylation depends on the transport of protons through the coupling factors
- Due to the oxidation of water & PQH_2, concentration of H^+ increases in the lumen of the thylakoid
- Because of concentration differences, protons try to move into the stroma
- Thylakoid membrane is impearmeable to H^+ ions
- H^+ ions pass through the CF complex into the stroma
- When $3H^+$ move down the potential gradient across the CF, the energy released will lead to the formation of ATP molecule
- For the transport of 6 protons ($6H^+$) through the CF complex, two ATP are produced
- Thus in non cyclic transport one NADPH + H^+ and two ATP molecules are synthesized for one molecule of water oxidized

Cyclic Electron Transport

- This was first demonstrated by Frenkel in the isolated chromatophores of bacterium called Rhodospirillum rubrum
- This occurs when PS-I operates independently
- It can be represented as follows
  $PS \rightarrow P_{700} \rightarrow Fd \rightarrow Cytb_6 \rightarrow PQ \rightarrow Cytf \rightarrow PC \rightarrow PS\text{-}IP_{700}*$
- Only ATP synthesis occurs. No NADPH + H+ is formed as it does not involve the photolysis of water

Dark Reaction

- It occurs in the stroma of the chloroplast
- The assimilatory power (ATP & NADHP +H^+) produced in light phase is utilized for the reduction of CO_2 to carbohydrate in dark phase
- Two pathways identified in dark phase are Calvin cycle & Hatch – Slack cycle

Calvin Cycle

- The events of CO_2 assimilation in C_3 plants were traced by Melvin Calvin, Benson & Basham
- Calvin cycle is also called as Photosynthetic carbon reduction cycle (PCR) or reduction
- Experimental material used by Calvin is Chlorella (a unicellular green alga)
- Isotype used by Calvin is ^{14}C(as $^{14}CO_2$)
- Calvin supplied $^{14}CO_2$ to the cultures of Chlorella to various periods (2 –60 seconds) before the cells were killed by transferring them to 80% hot methanol
- The compounds were identified by autoradiography
- When Chlorella was exposed to $^{14}CO_2$ for a period of less than two seconds, most of the tracer was incorporated in 3- phosphoglyceric acid (3 – PGA)

- 3-PGA is the first stable product (a C_3 compound) Hence Calvin is also C_3 pathway
- Calvin cycle includes three phases
  1) Carboxylation 2) Reduction 3) Regeneration

Carboxylation Phase

- The initial or primary acceptor of CO_2 in Calvin cycle is RUBP. (Ribulose 1, 5-biphosphate); a 5-carbon compound
- The first step in Calvin Cycle is carboxylation of RUBP. 3 molecules of CO_2 combine with 3 molecules of RUBP in presence of water to form 6 molecules of 3-PGA
- The enzyme catalysing the carboxylation is RUBP – carboxylase/oxygenase (RUBISCO)
- RUBISCO is the most abundant protein in the plant kindgom. It accounts for 25 –50% of soluble proteins in leaves

Reduction Phase

- Reduction of PGA requires ATP & NADPH $+H^+$
- Six molecules of 3-PGA combine with six molecules of ATP to form 6 molecules of 1-3-Bisphosphoglyceric acid. The enzyme catalysing the reaction in Phosphoglycerokinase
- Six molecules of 1, 3-Bisphosphoglyceric acid are reduced to six molecules of glyceraldehyde 3-phosphate in presence of 6NADPH $+H^+$
  The enzyme catalysing the reaction is glyceraldehyde 3-phospahte dehydrogenase
- Six molecules of glyceraldehyde 3-phosphate are termed as G_3 P-Pool
- For the uptake of 3 molecules of CO_2, one triose phosphate is available for export from chloroplast. Thus uptake of 6 molecules of CO_2 accounts for two triose phosphates (G-3P) which can be exported to cytosol, ultimately to form a hexose molecule

Note: The actual synthesis of hexoses (for storage) occurs in the cystosol

Regeneration Phase

- Out of the five molecules GAP meant for regeneration, two molecules are isomerised to dihydroxy acetone phosphate (DHAP) The reaction is catalysed by triose phosphate isomerase
  2GAP $\Leftrightarrow$ 2DHAP
  (3C) (3C)
- One molecule of GAP (3C) condenses with one molecule of DHAP (3C) to form one molecule of fructose 1 –6 bisphosphate (6C). The reaction is catalysed by enzyme aldolase
- One molecule of fructose 1, 6 biphosphate undergoes dephosphorylation to form fructose 6-phosphate. The reaction is catalysed by an enzyme fructose 1-6 bisphosphate
- Fructose 6-phosphate (6C) now combines with one molecule of GAP (3C) to form one molecule each of erythrose phosphate (4C) and xylulose-phosphate (5C). The reaction is catalysed by transketolase
- A molecule of erythrose phosphate (4C) combines with DHAP (3C) to form one molecule of sedoheptulose –1, 7- bisphosphate in presence of the enzyme transaldolase

- Sedopheptulase – 1, 7- bisphosphate undergoes dephosphorylation to form one molecule of sedoheptulose 7- phosphate. The reaction is catalysed by sedoheptulase 1, 7-biphosphate
- One molecule of sedophaptulase 7-phosphate (7C) combines with one molecule of GAP (3C) to form one molecule each of ribose 5 phosphate (5C) to xylulose 5-phosphate (5C) in presence of the enzyme transketolase
- Two molecules of Xylulose 5-phosphate are converted two molecules Ribulose –5 phosphate in presence of Ribulose 5 – phosphate epimerase
- One molecule of Ribose 5-phosphate is isomerised to one molecule of Ribulose 5-phosphate. The reaction is catalysed by Ribose 5-phosphate isomerase
- Thus the three molecules of Ribulose 5-phosphate of Ribulose 1- 5 bisphosphate. Three molecules of ATP are utilised by Ribulose – 5 – phosphate kinase

Energetic of Calvin Cycle

- For reducing $3CO_2$ molecules by Calvin cycle, a total of 6 molecules of $NADPH+H^+$ & 9 molecules of ATP is required
  In order to obtain a hexose sugar, 12 molecule of $NADPH+H^+$ and18 molecules of ATP are required

Hatch – Slack Cycle Pathway

- In 1965 H.P.Kortschak, Hatt 8 Burr found that 3-PGA is not the initial product of photosynthesis in sugarcane. Instead it was four carbon dicarboxylic acids like malic acids and aspartic acids
- M.D Hatch and C.R.Slack confirmed the above results in sugarcane
- C_4 cycle is also called Hatch – Slack cycle
- Prof.V.S.Rama Das from Andhra Pradesh has done extensive work on C_4 plants
- C4 pathway occurs in subtropical and tropical regions (Temperature range between 30^0C and 45^0C)
- 1500 species of angiosperm belonging to 19 families show this pathway
- C_4 plants can with stand drought and water stress conditions
- C_4 plants exhibit **kranz** anatomy in their leaves
- The chloroplasts of the bundle sheath cells are agranal while those of mesophyll cells are granal
- First (Primary) carboxylation occurs in the mesophyll cells and second carboxylation occurs in the bundle sheath cells
- The primary acceptor of CO_2 in C_4 plants
- The reaction is catalysed by PEP-carboxylase. (PEP case)
- The first stable product formed in a four carbon compound cells oxaloacertic acid (OAA)
- OAA is reduced to malic acid by using $NADPH_2$. The reaction is catalysed by the enzyme malic dehydrogenase (malate formers)
- Then some plants OAA undergoes transamination to form the amino acid aspertic acid (Asparate formers)
- Malic acid formed in the mesophyll cells is transported to bundle sheath cells through the plasmodesmata
- Malic acid undergoes oxidative decarboxylation to form pyruvic acid and CO_2. The enzyme involved is malic enzyme.
- $NADPH+H^+$ is liberated

- The CO_2 liberated in bundle sheath cells undergoes Calvin cycle
- Pyruvic acid produced in the bundle sheath cells moves into mesophyll cells where it is phosphorylated to phosphoenol pyruvate
- The enzyme catalysing the above reaction is pyruvate kinase
- Two molecules of ATP are used in phosphorylation
- Thus to reduce one CO_2 molecule in C_4 pathway, 5ATP are utilized. As such for the complete reduction of $6CO_2$ molecules, a total of 30 ATP are required

Factors influcing photosynthesis: Photosynthesis is affected by both external and internal factors

External Factors

- Light: The effect of light on photosynthesis is three fold i.e. quality intensity & duration
- Photosynthesis takes place in PAR (390 nm – 760 nm). Maximum photosynthesis occurs in Red light, followed by blue light. Green light is mostly reflected.
- Intensity: The rate of photosynthesis increases with the increase of intensity upto certain extent. Some plants may require low light intensity and grow in shady localities (Sciophytes) Some other plants in bright light (Heliophytes) However extreme light intensity may bring about solarization.
- A particular light intensity at which the amount of CO_2 released during respiration is equal to the amount of CO2 absorbed during photosynthesis is called **compensation point**.
- C_4 plants can tolerate higher light intensities
- Duration: The rate of photosynthesis is ore in intermittent light than in continuous light
- **Temperature**: Conifers can photosynthesis at -6^0C where as certain bacteria and cyano bacteria can perform photosynthesis at 70^0C. With increase in temperature from 10^0C to 40^0C, the rate of photosynthesis increases
- CO_2 concentration – As the CO_2 concentration increases upto 1%, there is an increase in the rate of photosynthesis. Increase beyond 1% will lead to toxicity of the chloroplast and stomatal closure.
- A point at which photosynthesis just compensates for respiration at particular level of CO_2 concentration in the atmosphere is called CO_2 Compression point. It is very high for C_3 plants as compared to C_4 plants
- Oxygen concentration – Increase of O_2 concentration inhibits the rate of photosynthesis. This is called Warburg effect.
- High O_2 concentration leads to photorespiration
- Water: Photosynthetic rate decreases with water deficiency. When water becomes limiting it will effect cellular expansion, CO_2 absorption and enzyme efficiency. Water is donor of electron and protons

Internal Factors

- Chlorophyll content: The amount of chlorophyll has direct effect on photosynthesis. In darkness, etiolation occurs and photosynthesis decreases. Chlorophyll content decreases with the age of the leaf
- Internal structure of leaf – The thickness of the cuticle and epidermis, structure and distribution of stomata and proportion of mysophyll tissue will influence the rate of photosynthesis
- Accumulation of end products – Accumlation of photosynthesis will lead to the decrease of the process. This is due to feed back inhibition

- In C_4 plants, the presence of bundle sheath facilitates an immediate translocation of food into the conducting tissues
- Blackmann's law of limiting factors – This is proposed by F F Blackmann in 1905
- When the rate of photosynthesis is controlled by more than one factor, the rate of the process is controlled by the smallest available factor which is called as limiting factor
- At low concentration of the limiting factor, an increase of the factor also increases the rate of the process proportionately. At higher concentration of the factor

RESPIRATION

- Respiration is a catabolic, enzyme mediated oxidative process
- It is an energy releasing process (Exergonic)
- The C-C –bonds of food material and organic acids are broken down in respiration
- Mitochondria are associated with respiration
- The inner mitochondrial membrane is involved in energy transduction
- The gap between the two membrane of the mitochondrial is called as perimitochondrial space
- The invaginations of the inner mitochondrial membranes are called as Critae/mitochondrial crests
- The inner membrane is selectively permeable to a few molecules likeO_2, CO_2 & H_2O
- The permeability of the inner membrane to protons is very low, or absent. This is a significant factor for ATP synthesis
- The stalked particles on the cristae are called $F_0 – F_1$ complex. (Formerly called oxysomes or elementary particles)
- The mitochondrial matrix contains 70% of respiratory enzymes, 70S type of ribosomes, circular DNA, RNA & several ions
- In respiration energy is released in the form of heat or ATP
- ATP is called as the energy currency of the cell
- The energy present in the ATP can be immediately released whenever needed
- The ATP molecules can move within a cell from one place to the other
- ATP is a nucleotide consisting of three constituents
  i) A nitrogen base adenine
  ii) A five carbon sugar ribose
  iii) Three inorganic phosphates (α,β and γ)
- The bond attaching the last phosphate (γ) to the rest of the molecule is a high energy bond
- When this bond is hydrolysed it yields 7.6Kcal of energy
- In addition the sugars are modified to form the carbon skeletons that make up the basic building blocks of cell
- Respiration is of two types
  Aerobic respiration occurs in presence of O_2
  $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + 688$ K.cal
  Anerobic respiration occurs in absence of O_2
  $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2 + 56$K.cal
- Aerobic respiration leads to complete oxidation of glucose molecule involving four different stages They are:
  a) Glycolysis
  b) Oxidative decarboxylation of pyruvic acid
  c) Krebs cycle

d) Electron transport

- Aerobic respiration involves six oxidation (dehydrogenation) reactions
(1 in Glycolysis, 1 in oxidative decarboxylation of pyruvic acid and 4 in Kreb's cycle)

Glycolysis:

- The incomplete oxidation of glucose into two molecules of **pyruvic acid** in series of steps is called **glycolysis**
- Glycolysis is the **first phase** of respiration No of oxygen is used in the process
- The **common phase** for both aerobic and anaerobic respirations is glycolysis
- Glycolysis occurs in the **cytoplasm/Cytosol**
- The various steps of glycolysis were discovered by **Embden**, **Meyerhof** and **Paranas**
- They discovered these steps of glycolysis while studying **the fermentation of glucose by yeast** and oxidation of **glycogen in tissues** of **animal muscles**
- **W.O.James** called glycolysis as **core respiration**
- Equation representing glycolysis is
$C_6H_{12}O_6 + 2\,(ADP + i\,P) + 2\,NAD^+ \rightarrow 2CH_3CO.COOH + 2ATP$
$+ 2NADH + H^+ + 2H_2O$
- **Glucose** and **ATP** are required by living cells to start glycolysis
- **Phosphorylation of glucose** is the first step of glycolysis
- Phosphorylation of glucose is catalyzed by enzyme **hexokinase** (**glucose 6-phosphotransferase**)
- Second phosphorylation in glycolysis occurs when **Fructose –6 phosphate** is converted into **Fructose –1, 6 –bisphosphate** by **phosphofructokinase**
- Enzymes **hexokinase** and **phosphofructokinase** require **Mg^{+2} ions**
- The enzymes **aldolase** splits fructose – 6 – bisphosphate into two trioses
- The trioses are **GAP** and **DHAP**
- These trioses are **interconvertable**
- GAP is also known as **PGAL** and **G.3.P**
- The process of conversion of DHAP to GAP is **isomerization**
- A triose **suitable** for biological oxidation is **GAP**
- A triose **is not suitable** for biological oxidation is **DHAP**
- GAP **undergoes oxidation** to form DPGA (1, 3, diphosphoglyceric acid)
- During the oxidation of GAP, NAD is reduced to $NADH + H^+$ and a molecule of $H_2PO_4^-$ is used
- **Number of oxidation** reactions that occur in glycolysis is **One**
- **Number of NAD** molecules reduced in glycolysis is **2**.
- **Number of dephosphorylations** of glycolysis is **2**.
- Number of stages at which dephosphorylations occur is **2** (**substrate level phosphorylations**)
I) BPGA + ADP $\rightarrow$ PGA + ATP
II) PEP + ADP $\rightarrow$ Pyruvic acid + ATP
- Enzymes **phosphoglycero kinase** and **pyruvic kinase** which catalyse diphosphorylation require **co-facotr Mg^{+2}**
- ATP formed during glycolysis is by **substrate level phosphorylation** or **transphosphorylation**
- The enzyme enolase catalyses dehydration reaction of glycolysis
(2PGA $\rightarrow$ PEP $+H_2O$).
- Number of **ATP** formed during glycolysis is **4**.

- Number of **ATP** used in glycolysis is **2** (one when glucose is converted to glucose-6-phosphate and second one when Fructose –6-phosphate is converted to fructose, 1-6-bisphosphate)
- **Net gain** of **ATP** in glycolysis is **2**.
- **Net gain** of glycolysis is **2ATP** and **2NADH$_2$**.
- The **end product** of glycolysis is **pyruvic acid** (2 molecules)
- Pyruvic acid is the **common intermediate substance** of aerobic and anaerobic respirations
- In glycolysis **O_2** is not **utilized** and **CO_2** is not released

Oxidative decarboxylation of pyruvic acid

- The conversation of pyruvic acid into acetyl Co.A is called **oxidative decarboxylation**
- Product of glycolysis that enters mitochondria is **pyruvic acid**
- In oxidative decarboxylation pyruvic acid undergoes **oxidation** (**dehydrogenation**), **decarboxylation** and **condensation**
- Oxydative decarboxylation of **pyruvic acid** into **acetyl co.A** occurs in **mitochondrial matrix**
- It is catalysed by **multienzyme complex** known as **pyruvic dehydrogenase complex** (pyruvic oxidase)
- Pyruvic dehydrogenase complex is present in the matrix of mitochondria. This is a cluster of three enzymes. They are Pyruvate decarboxylase, Dihydro lipoyl transacetylase and Dihydro lipoyl dehydrogenase
- For the formation of Acetyl CoA six **cofactors are required**
- The six co-factors are **thiamine pyrophosphate** (TPP), **Lipoic acid** (LP), **NAD^+**, **Coenzyme-A** (Co-A) and **Mg^{+2}** and **FAD**
- The product of oxidative decarboxylation of Pyruvic acid is a two carbon compound called **acetyl co.A**
- Pyruvic acid enters Kreb's cycle in the form of Acetyl Co.A
- Acetyl Co.A is the connecting link between glycolysis and Kreb's cycle
- Connecting reaction between glycolysis and Kreb's cycle is oxidative decarboxylation of pyruvic acid
- The two molecules of pyruvic acid produced in glycolysis undergo oxidative decarboxylation to form 2NADH + H^+ and $2CO_2$

Krebs Cycle

- The complete oxidation of acetyl Co.A (pyruvic acid) into CO_2 and water occurs through Krebs cycle
- Krebs cycle occurs in **mitochondrial matrix**
- The concerned enzymes of Kreb's cycle are present in the mitochondrial matrix
- Kreb's cycle is also known as **TCA cycle** or **citric acid cycle** or **organic acid cycle** or **mitochondrial respiration**
- The **substrate** for Kreb's cycle is **acetyl Co.A**.
- Number of biochemical reactions in Kreb's cycle is – ten
- Opening face (door) of Kreb's cycle is – OAA (oxaloaceticacid)
- The first reaction of Kreb's cycle is **condensation** of acetyl Co.A with OAA and H_2O to form citric acid
- **Citric acid** is the **first product** of Kreb's cycle
- Enzyme **aconitase** catalyses the conversion of citric acid to isocitricacid
- Conversion of isocitric acid to oxalosuccinic acid is **first oxidation** step in Kreb's cycle
- Citric acid is the first **tricarboxylic acid** of Kreb's cycle
- **First decarboxylation** occurs in conversion of oxalosuccinic acid to α **-**ketoblutaric acid

- α-ketoglutaric acid is **the first** and **only 5** carbon intermediate acid to Kreb's cycle
- The intermediate substance of Kreb's cycle that undergoes **oxidation** and **decarboxylation** is **α-ketoglutaric acid**
- The **first 4-carbon** compound formed in Kreb's cycle is **succinyl Co.A**
- Reactions involved in the formation of succinyl Co.A is oxidation, decarboxylation and condensation
- The **only substrate level phosphorylation** step in Kreb's cycle is formation of **succinic acid** from **succinyl Co.A**
- During the conversion of succinic acid to fumaric acid (oxidation) a molecule of **FAD** is reduced to $FADH_2$.
- The hydrogen released from substrate succinic acid is accepted by FAD
- The steps of Kreb's cycle which involve no energy liberation is dehydration of citric acid to cis-aconitic acid, cis-aconitic acid to isocitric acid, conversion of oxalosuccinic acid to α-ketoglutaric acid and hydration of fumaric acid to malic acid
- Number of decarboxylation steps during Kreb's cycle is **2**.
  I) Oxalosuccinicacid $\rightarrow$ α-ketoglutaric acid
  II) α-ketoglutaric acid $\rightarrow$ succinyl co.A
- **Final oxidation** in Kreb's cycle occurs when malic acid is converted to oxaloacetic acid; one NAD is reduced to $NADH_2$
- **Number of oxidation steps** during Kreb's cycle is **4**.
  I) Isocitiric acid $\rightarrow$ Oxalosuccinic acid
  II) α-ketoglutaric acid $\rightarrow$ Succinyl co.A
  III) Succinic acid $\rightarrow$ Fumaric acid
  IV) Malic acid $\rightarrow$ Oxaloacetic acid
- **Irreversible reactions** of Kreb's cycle are
  I) OAA + acetyl Co.A + H_2O $\rightarrow$ Citric acid
  II) α-ketoglutaric acid $\rightarrow$ Succinyl acid
- **A 5 –carbon dicarboxylic** acid formed during Kreb's cycle is α-ketoglutaric acid
- An **intermediate substance** of Kreb's cycle useful **in synthesis of amino acids** is α-ketoglutaric acid
- **Six carbon compounds** of Kreb's cycle are **citric acid**, **cis-aconitic acid**, **isocitric acid** and **oxalosucinic acid**
- **Five carbon** compound of Kreb's cycle is **α-ketoglutaric acid**
- **Four carbon** compounds of Kreb's cycle are **succinyl Co.A**, **succinic acid**, **Fumaric acid**, **Malic acid** and **Oxaloacetic acid**
- In one turn of Kreb's cycle, complete oxidation of acetyl Co.A forms –**3$NADH_2$**, **1$FADH_2$** and **ATP** (GTP) (12ATP)
- NAD^+ is known as **universal hydrogen aceptor** or **Co-enzyme-I**
- Oxidation of food molecules and generation of ATP are important characters of Kreb's cycle
- Kreb's cycle is a central metabolic pathway playing an important role in both catabolism & anabolism
- The catobolic role is that it is responsible for oxidation of carbohydrates
- The anabolic role is that the α-ketoglutaric acid formed as an intermediate is responsible for the synthesis of amino acids
- Thus the term Amphibolic (dual purpose) is used to signify Kreb's cycle

Balance sheet of Aerobic respiration

Glycolysis:

- ATP produced by
  substrate level phosphylation - 4ATP
  ATP consumption - 2ATP
  Net gain of ATP (4 –2) = 2ATP
- ATP produced by oxidative phosphyralation
  2NADH +H^+ (2 x 2) = 4ATP
  Total ATP produced during aerobic glycolysis = 6ATP
- Oxidation decarboxylation of Pyruvic acid 2NADH + H^+ (2x3) = 6ATP
- Kreb's cycle
  3NADH + H^+ = 3x3 = 9
  1$FADH_2$ = 2x1 = 2 x 2 = 24ATP
  Substrate level phosphyralation 1 Total = 36ATP

Energitics of Aerobic Respiration

- One glucose molecule on complete oxidation forms 36ATP
- One 1 ATP yields = 7.6K cal of energy
- Energy liberated is 7.6 x 36 = 273.6 K cal
- The remaining energy, i.e. 686 – 273.6 = 412.4 K cal is released as heat

Mechanism of anaerobic respiration

- Occurs in the absence of O2, Organisms which carry out this respiration are called anaerobes
- Anaerobes may be obligate or facultative
- Obligate anaerobes cannot survive in the presence of O_2
  Ex: Clostridium botulinum
- Facultative anaerobes can tolerate aerobic conditions Ex: Yields
- Anaerobics respiration occurs in two steps
  a) Glycolysis b) Fermentation

- Glucose
  $\downarrow$ Glycolysis
  Pyruvic acid
  Pyruvic decarboxylase $\downarrow \rightarrow CO_2$
  Acetaldehyde
  NADH + H^+
  Alcohol dehydrogenase $\downarrow$ $\downarrow$
  NAD^+
  Ethyl alcohol

- The net gain of ATP in anaerobic respiration is two

Alcoholic Fermentation

- First reported by Gay Lussac & the term Fermentation was coined by L Pasteur
- First step is alcoholic fermentation is decarboxylation of pyruvic acid to acetaldehyde of the enzyme pyruvic decarboxylase
- The second step is reduction Acetaldehyde is reduced to ethyl alcohol in presence of NADH + H^+. The reaction is catalysed by the enzyme alcohol dehydrogenase
- Alcoholic fermentation is used in preperation of beverages
- It is also used in bread making

Respiratory Quotient (RQ)

- RQ is the ratio between volume of CO_2 evolved and volume of O_2 consumed
- RQ is an index of the respiratory substrate used

- RQ differs according to the type of respiratory substrate
- RQ is measured by an instrument called Ganong's respirometer
- RQ for carbohydrates is unity (i.e. one)
- Fats are poorer in O_2 More O_2 is consumed for their oxidation. As such RQ of fats is less than one
  For triolein, RQ value is 0.7
  For oleic acid, RQ value is 0.71
  For tripalmitin, RQ value is 0.7
- Proteins are generally not used as respiratory substrate except under prolonged starvation conditions. They are also deficit of O_2. As such their RQ is also less than one. Generally the RQ of proteins ranges between 0.8 and 0.9
- Organic acids are rich in O_2. As such less O_2 is consumed for their oxidation. The RQ values of organic acids are
  Malic acid - 1.33
  Tartaric acid – 1.6
  Oxalic acid - 4

Nitrogen Metabolism

- The utilization of nitrogen in various metabolic processes is known as Nitrogen Metabolism
- Nitrogen is one of the soil nutrients required by plants in large quantities
- It is a major constituents of protoplasm after carbon, hydrogen and oxygen (fourth abundant element in the plant body)
- It is structural constituent of many organic compounds – amino acids, proteins enzymes, co-enzymes, nucleic acids (purines and pyrimidines) of DNA and RNA, chlorophylls, cytochromes, vitamins, alkaloids and harmones
- The atmosphere contains about 78% of nitrogen or dinitrogen. It is present in molecular form. Two nitrogen atoms in nitrogen molecule are joined by triple bond.
- The higher plants cannot utilise molecular nitrogen
- The atmospheric nitrogen entering the plant cannot be fixed (due to absence of enzymes which break triple bond) and hence diffuses out into the atmosphere
- Only prokaryotes (Bacteria and Cyanobacteria) and Actinomycetes can utilise atmospheric nitrogen
- They contain special genes called nif genes which are responsible for the production of enzyme dinitrogenase
- With the help of this enzyme they convert atmospheric nitrogen into nitrogenous compounds through nitrogen fixation
- After nitrogen fixation, nitrogenous compounds are added to the soil to make them available to the higher plants which absorb them by the roots
- Nitrogen is available to the plants in four forms
  1) Nitrate nitrogen   2) Ammonia nitrogen
  3) Organic nitrogen   4) Molecular nitrogen
- Higher plants can utilise nitrate (NO_3^-), ammonia nitrogen (NH_4^+) and organic nitrogen (urea) but not molecular nitrogen
- Nitrate nitrogen absorbed from the soil by the roots of higher plants is not directly utilised but must be reduced to ammonia before it is incorporated into nitrogen compounds of the plant

- The reduction of nitrate to ammonia is brought about the activity of two enzymes, nitrate reductase and nitrite reductase

$$\underset{\text{Nitrate}}{NO_3^-} + 2H^+ + 2e^- \xrightarrow{\text{Nitrate reductase}} \underset{\text{Nitrite}}{NO_2^-} + H_2O$$

$$\underset{\text{Nitrite}}{NO_2^-} + 8H^+ + 6e^- \xrightarrow{\text{Nitric reductase}} \underset{\text{Ammonium}}{NH_4^+} + 2H_2O$$

- Similarly urea will be converted to NH_4^+ by the catalytic activity of 'urease'
- Nitrogen assimilation in plants involves three steps. They are
  Nitrogen fixation
  Aminoacid synthesis
  Synthesis of proteins
- Nitrogen fixation is of three types
  Physical nitrogen fixation
  Chemical nitrogen fixation and
  Biological nitrogen fixation
- Physical nitrogen fixation occurs in the atmosphere
- Chemical nitrogen fixation is brought about by Haber-Bosch process
- Nitrogen fixation carried out by prokaryotes and actinomycetes is called **Biological nitrogen fixation** or **diazotrophy** and the organisms involved in nitrogen fixation are called **nitrogen fixers** or **diazotrophs**
- Biological nitrogen fixation is again divided into
  Asymbiotic or non-symbiotic nitrogen fixation
  Symbiotic nitrogen fixation

Nitrogen Fixing Organisms

- Free living organisms (*non symbiotic systems*)
  Bacteria: Aerobic bacteria Asymbiotic or non-symboitic nitrogen fixing Bacteria
- A free living, saprophytic anaerobic, nitrogen fixing bacterium is *Clostridium pasteurianum*
- A free living, saprophytic, aerobic, nitrogen fixing bacterium is *Azotobacter*
- All photosynthetic bacteria which are obligate anaerobes are nitrogen fixing bacteria ex: *Chlorobium*, *Chromatium*, *Rhodospirillum*
  Cyanobacteria (Blue green algae)
  Symbiotic nitrogen fixing filamentous blue green algae with heterocysts are Nostoc, *Anabaena* etc,

Symbiotic nitrogen fixation:

Bacteria:

- The most common symbiotic nitrogen fixing bacterium found in the root nodules of leguminous plants is *Rhizobium leguminosarum* or *Bacillus radicicola*
- A non-leguminous angiospermic plant in which root nodules have *Rhizobium* sps *Parasponia*

Actinomycetes:

- Nearly 13 genera of non-leguminous angiosperms which are all woody dicots and containing actinomycetes *Frankia* in their root nodules are *Alnus*, *Casuarina*, *Myrica* etc
- The leaf nodules in *Psychotria* contain nitrogen fixing bacterium *Klebsiella*

Cyanobacteria:

- The angiosperms plant in which underground stem (stem glands) showing symbiotic association with *Nostoc* is *Gunnera* sps

- The corolloid roots of Cycas (Gymn sperm) contain nitrogen fixing cyanobacteria namely *Anabaena cycadacearum* and *Nostoc punctiforme*
- The leaves of *Azolla* (poteridophyte) contain nitrogen fixing blue green alga *Anabaena azollae*
- The thallus in *Anthoceros* (Bryophyte) contain nitrogen fixing alga *Nostoc*
- Lichens are the composite organisms formed of fungal partners (Mycobionts).
  ex: some actinomycetes and Basidiomycetes and algal partners
  ex: Nostoc and Anabaena (Cyanobacteria).
  These cyanobacteria take part in nitrogen fixation

Symbiotic nitrogen fixation in legumes:

- The most common symbiotic nitrogen fixing bacterium found in the root nodules of leguminous plants is *Rhizobium leguminosarum* or *Bacilus radicicola*
- It is gram '-'ve, aerobic and present in the soil as a saprophyte
- The roots of legumes secrete some growth factors, sugars, aminoacids and flavonoids into the soil and *Rhizobia* cluster around the root hairs
- Due to infection, multiplication and secretion of curling factor by *Rhizobium*, the root hairs become curled called shpherds crook
- The host recognises compatible bacteria by specific plant protein called **lectins**
- The bacteria invade at the site of curling or deformation
- *Rhizobium* bacteria produce cell wall digesting enzymes (cellulase and pectinase, etc,) which degrade the cell wall of the root hairs of the host plant
- The plasma membrane becomes greatly folded (invaginated) into which the invading bacteria enter forming an infection thread
- The infection thread extends into inner cortical cells
- The bacteria are ultimately released into the corticel cells with the dissolution of sheath or plasma membrane. They begin to multiply
- The cortical cells of host produce phytohormones which induce rapid cell division in the cortex leading to the development of root nodule
- Actively dividing bacteria inside the infected host cells transform into swollen structures called **bacteroids**.
- Bacteroids of nodules differ from *Rhizobium* present in the soil in structure and function
- *Rhizobia* in the soil are rod shaped without a functional nitrogenase enzyme whereas bacteroids are irregular in shape containing nitrogenase enzyme
- The bacteriods are bounded by *peribacteroid membrane* derived from the host cells

Mechanism of biological nitrogen fixation

- In the bacteriods the enzyme dinitrogenase (as they contain a set of genes called nif genes) is synthesis. It important role in nitrogen fixation
- The enzyme Nitrogenase contains two proteins
  1) Fe protein and 2) Fe-Mo protein
- Root nodules contain a red pigment **leghanemoglobin** which is remarkably similar in properties to haemoglobin of RBC
- The enzyme 'Nitrogenase' is highly sensitive to oxygen and its activity is inhibited (denatured) in the presence of O_2
- Leghaemoglobin has a high affinity to oxygen & combines rapidly with oxygen and acts as oxygen scavenger

- Due to high affinity to oxygen, leghaemoglobin, maintains low oxygen tension in the nodule so that the activity of enzyme ‘nitrogenase’ goes on at optimum rate
- Leghaemoglobin which has combined with O_2, supplies O_2 for respiration (aerobic bacteria) in which ATP for nitrogen fixation is released
- Leghaemoglobin separates two opposite metabolic processes in nitrogen fixation (requires O_2 free environment and respiration) (requiring O_2) It is called ‘metabolic compartmentation’ of incompatible activities
- In heterocystous cyanobacteria ex: *Nostoc* nitrogenase is protected in heterocysts
- The overall reaction in the conversion of dinitrogen into ammonia is
  $N_2 + 8e^- + 8^+ + 16\ ATP \rightarrow 2NH_3 + H_2 + 16ADP + 16Pi$
- The source of protons, electrons and ATP may vary in different nitrogen fixing systems but the basic mechanism is same in all of them
- The electron donor for the enzyme nitrogenase is ferredoxin which receives electrons in respiration

Genetic code:

- The corresponding relationship between the sequence of four bases in DNA/RNA and the sequence of aminoacids is a polypetide chain is **genetic code.,**
- The genetic code and codon dictionary (which codon codes for which amino acid) were given by **Marshall Nirenberg**, **Hargobind Khorana** and **Holley**

Important properties of genetic code:

I) The genetic code is triplet code:

- A code consisting of one nitrogen base (A, U, G, C) called singlet code can code only 4 amino acids, which is inadequate
- A code consisting of two nitrogen bases called doublet code (ex: AU, GU, GC etc) (4x4) can code 16 amino acids which is inadequate
- Triplet code consisting of three nitrogen bases forming 64 triplets (4x4x4) is adequate to code for twenty aminoacids. Such triplet bases present on m-RNA which specify 20 amino acids are called **codons**
- There are 64 codons out of which 61 codons specify 20 amino acids
- The three remaining triplets UAA (**ochre**), UAG (**Amber**) and UGA (**opal or umber**) do not specify for any amino acid and serve for the termination of polypeptide chain (only one of them is present at 3’ end of mRNA) and are called **non-sence codons** or **termination codons**
- In prokaryotes AUG/GUG present at the beginning of the m-RNA (5’end) is act as an initiating codon or starting codon. If specifies N-formyl methionine

II) Genetic code is degenerate: There are 64 codons in a triplet code out of which 61 codons code for 20 amino acids. Since there are more number of codons than the number of amino acids to be coded it is obvious that more than one codon codes for an amino acid. (except tryptophan and methionine which are coded by a single codon)

ex: Serine is coded by UCU, UCC, UCA, UCG
Proline is coded by CCU, CCC, CCA, CCG
Lysine is coded by AAA, AAG

III) Genetic code is non- overlapping: No single base can take part in the formation of more than one codon. The nitrogen base used for one codon is not used for the next codon (or) the number of amino acids coded in a polypetide chain is equal to the number of codons on m-RNA

ex: UUU CCC = UUU – Phenyl alamine, CCC – proline

AACCGA = AAC – Aspargine; CGA – Arginine

IV) Genetic code is commaless: In between triplet codes no letters are wasted. There are no punctuations (comma) or non-coding triplets or intermediarly nucleotides between the codons

V) Genetic code is non-ambiguous: A particular codon will code for the same amino acid.

VI) The code is universal: The same code applied to all kinds of living organism

ex: UUU codes for phenylalamine in all living organisms

PLANT GROWTH REGULATORS

[PHYTOHORMONES]

- Plant growth is complex & complicated. It is defined as permanent & irreversible change in size of cell, organ or organism accompanied by increase in dry weight. Growth is the result of many vital processes like cell division, cell elongation, cell differenciation & morphogenesis. These processes are controlled by 2 sets of internal factors -----

Nutritional factor	Hormonal factor
Supply mineral ions & organic substances	Regulats utilization of nutrients & bring coordination between different parts of plants

- According Julius Von Sachs (1880) hormonal factors are referred as "Chemical Messengers". These chemical messengers are known as phytohormores
- Phytohormone is defined as "an organic substance synthesised in one part of plant body & moves to the site of action & cause physiological response in very low concentration".
- Phytohormones are also known as plant growth regulators as their main function is to regulate growth

Growth Regulators

Growth promoting substances	Growth Inhibiting substances
↓	↓
"growth regulators which promote growth". (growth promotors)	"growth regulators which inhibit growth"
Ex: Auxins Gibberellins,Cytokinins	Ex: Ethylene, Abscisic acid

<u>AUXINS</u>: The term auxin is derived from Greek word Auxin = to grow / increase

- Auxins are the phytohormones which promote longitudinal growth in plants. Chemically they are the derivatives of Indole compounds
- Darwin & his son Francis Darwin (1891) published the book "The Power of Movement in Plants".
- They described phototropism in coleoptiles of Canary grass i.e. Phalaries canariensis & reported that when coleoptiles are exposed to unilateral light, coleopticle bends towards light.

- Dutch scientist Boysen – Jensen (1910) reported that a diffusable substance is synthesised at the tips of coleptiles and transported downwards & is responsible for phototropism
- Dutch plant physiologist F.W.Went (1928) isolated the substance c cause phototropic curvature from the coleptiles of Avena sativa (Oat). He conducted Avena coleoptile curvature test

Avena Curvature Test:

- Went germinated pure grains of Oat on artificial medium. He cut the tips of coleptiles & placed them on agar block.
- After some time he removed the tips from agar block.
- He placed the agar block centrally on the stumps of coleoptiles. Which showed longitudinal growth.
- In another experiment Went placed treated agar acentrically on decpitated coleoptiles.
- The coleoptiles showed curvature. He concluded that hormones migrated from only one side & curvature is due to more growth on hormone side. Such tests using the response of biological material to test the activity of substance is known as BIOASSAYS
- The most active type of naturally occuring auxim is Indole –3 – acetic acid (IAA).
- The other naturally occuring auxins are 4 –chloro IAA, PAA (phenyl acetic acid), but their significance is very less in plant growth
- Plant physiologist synthesized synthetic substances which behaves as natural auxins. These substances are known as synthetic auxins. Some examples of synthetic auxins are IBA, NAA, 2, 4-Dichlorophenoxy acetic acid (2, 4- D). 2, 4, 5 – T etc. Synthetic auxins are widely used in agriculture & horticulture

Synthesis Of Auxins:

- Auxins are synthesised in the growing apical regions mainly in shoot apex & to some extent root apex.
- The natural auxin IAA is synthesised from amino acid 'Tryptophan' & Zn is necessary for IAA synthesis
- Auxins synthesised is the apical regions are transported both towards the apex (acropetal) & towards the base (basipetal), but basipetal transport is more predominant

PHYSIOLOGICAL EFFECT:

- Auxins bring about various physiological effects such as ----

1) Cell elongation:

- The most characteristic action of auxin is to promote cell enlargement & induce growth in stem tissue cultures & coleptiles.
- Cell enlargement is due to increase in the content of cell, cell permeability, synthesis of specific RNA & proteins which increase the cell wall plasticity. They also induce cell differenciation

2) Root invitation:

- Auxins like IAA induce formation of roots on stem cuttings.
- Synthetic auxins like IBA, NAA are more efficient in inducing roots on stem cutting as compared to natural auxin IAA. Among all auxins IBA is proved to be highly efficient in inducing root formation in stem cutting

3) Tropic movements:

- Tropic movement are growth movements or curvatures induced in growing regions of plant body by unilateral effect of external stimulus
- "The growth movements is which a relation exists between the direction of stimulus & direction of response" is known as tropic movements
- Movement in response to light – Phototropism
- Movement in response to gravity - geotropism
- Phototropic movements are influenced by auxins c is explained by Cholodny – Went Theory

Phototropism: It is influenced by auxins & can be explained by experiment with coleoptiles.

- Coleoptiles are taken & kept straight. They are exposed to unilateral light. After few days coleoptiles bend towards light. Auxins present towards light exposed part are destroyed due to photo – oxidation which results in low conc of auxins Cell elongation is more in shaded side (due to high auxin conc) & less in light exposed part (due to low auxin conc). This unequal elongation results in bending of coleoptiles towards light.

Geotropism: The movements of growth & curvature in response to gravitational force ---- geotropism. The role of auxin in geotropism can be explained by experiment with seedlings.

- A seedling is taken & kept horizontally. Due to basipetal transport, auxins are accumulated in the lower side of seedling. In the stem part of seedling, cell elongation is more on the lower side (because of high conc of auxins) as a result
- stem tip bends upwards (i.e. negative geotropism). In the root part of seedling, cell elongation is more on the upper side (because of low conc of auxins which favours more growth in roots. This results in bending of root towards the lower side (i.e. positive geotropism).

4) Apical Dominance:

- The phenomenon of "suppression of growth of auxillary bud by actively growing apical bud is known as apical dominance". It can be removed by the removal of apical bud. It is experimentally proved by Thimann & Skoog (1934) that auxins are responsible for apical dominance. Because of accumulation of auxins in high concentration, growth of axillary bud is inhibited. If apical bud is removed, axillary buds develops into branchest.

5) Parthenocarpy:

- 'Development of fruit without fertilization is known as parthenocarpy'. These fruits are seedless.
- Auxins induce parthenocarpy. The role of auxins to induce parthenocarpy was first observed in Orchids.
- Yasuda (1934) applied pollen extract (which is rich in auxins) to flowers of cucumber & produced parthenocarpic fruits
- Gustafson (1936) applied IAA to the stigmas of flowers & produced parthenocarpic fruits

6) Sex determination:

- High conc of auxins favours formation of female flowers in Cucumber.
- In Cucumber production of male flowers is more as compared to female flowers.
- Spraying high conc of auxins favours the formation of female flowers.

GIBBERELLINS:

- These are the plant growth regulators which promotes internodal elongation & flowering.
- Chemically they are diterpenoids.
- Gibberellins were first discovered in Rice plant by Japnese scientist in the beginning of 20^{th} century Japanese Scientiest Kurasawa reported Bakanae disease (foolish seedling disease) in seedling of rice. This disease is caused by fungus Giberella fujikori (fusarium monoliformae).
- The infected seedling were tall, thin & pale.
- The excessive growth of seedling is due chemical substance secreted by the fungus. In 1938, Yabuta & Sumuki isolated the chemical in crystalline form & name it as Giberellic acid.
- Later many gibberellins are extracted & identified.
- Gibberellins are large group of naturally occuring phytohormores. All gibberellins are assigned an 'A' number(GA_1, GA_2----) They are synthesised in the apicies of immature leaves, & root tips. They are present in high conc in fruits & germinating seeds. They are trans located through Xylem.

Physiological Effects of Gibberellins: Some important effects of gibberellins are ----

1) Removal of Genetic Dwarfism (Stem Elongation):

- Gibberellins promotes internodal elongation in several plants
- Genettic dwarf plants are present in bean, maize & some other plants. The dwarfism is due to the presence of low concentration of gibberellins. If gibblerellins are applied, dwarf plants grow to normal size
- In rosette plants like cabbage, carrot, radish etc, stem is condensed with crowded leaves. The internodes are short. They elongate before flowering. The elongation of internodes before flowering is known as 'Botting'. Application of gibberellins promote botting in three plants

2) Flowering:

- Gibberellins promote flowering in many plants. In rosette plants like cabbage, radish & carrot etc, botting is followed by flowering.

3) Parthenocarpy:

- Gibberellins induce formation of parthenocarpic fruits in tomato, apple, grapes etc

4) Seed Germination:

- Gibberellins promote the germination of cereal seeds such as barley, wheat, rice etc, by increasing the synthesis of amylase, RNA & proteins. Amylase helps in hydrolyses of starch in endosperm which leads to the formation of sugars. From sugars, energy is liberated which is utilized in seed germination

5) Breaking Dormancy:

- "Temporary suspension of growth & metabolism is known as dormancy. During unfavorable condition, dormancy is imposed in buds & seeds which can be removed by gibberellins

CYTOKININS:

- These are the growth regulators which promotes cell division & photomorphogenesis chemically they are the derivatives of adenine. Presence of unknown compound
  (which cause cell division) in endosperm, & fruits was first demonstrated by Haberlandt (1913).
- Van Overbeek (1914) cultured embryos of Datura in coconut milk.

- Skoog & Miller discovered a compound which is formed by partial breakdown of herring (marine fish) sperm DNA. They named this compound as 'Kinetin' because of its activity in inducing cytokinesis.
- Miller & Letham (1965) isolated naturally occuring cytokinin in pure crystalline form from endosperm of maize & named it as Zeatin.
- Cytokinins are distributed in apical meristem immature leaves, developing endosperms & fruits etc.

Physiological Effects:

- Some important physiological effects of cytokinenins are ----

1) Cell Division:

- cytokinins induce cell division by enhancing the synthesis of DNA, mRNA, tRNA

2) Morphogenesis:

- Cytokinins promotes development of buds in the leaves of Begonia, buds on protonema of mosses, Cytokinins & auxins induce photomorphogenesis in tissue culture. They also induce differenciation of proplastids into chloroplast.

3) Delay in Senescence:

- "Aging of plant plants due to degradation of chlorophyll, RNA, protein etc is known as senescence". It is followed by death of organ or whole plant.
- Cytokinins delay the process of senescence Application of cytokinins prevents the drooping of immature leaves, unpollinated flowers, immature fruits etc. When cytokinins are applied on a particular spot on leaf undergoing senescence, the spot remains green for several days. This effect of cytokinins to delay the process of senescence is known as "Richmond – lang effect"

4) Opening of Stomata:

- Cytokinins increases K^+ ion concentration in guard cells & helps in the opening of stomata.

ABSCISIC ACID (ABA):

- It is a growth regulator which inhabit growth & promotes dormany. Chemically it is a 15 –carbon terpenoid compound (sesquiterpene)
- Addicot & his co-workers isolated two active compound which are responsible for abscission from cotton fruit & named them as absin – I & absin – II
- Wareing & his co-workers (1963) isolated dormancy inducing substance from Acer Ieaves & nomed it as dormin
- Absin – II & dormin are structurally similar & a common name 'Abscisic acid' was given in 1967.
- Abscisic acid is present in all vascular plants & also in some mosses, algae & fungi. It is present in high concentration in dormant seeds, buds & scenscent leaves.
- Abscisic acid concentration increases under stress condition & inhibit growth; & hence also known as "Stress hormone".

Physiological Effects of ABA:

- ABA inhibits many physiological activities in plants. such as ----

1) Abscission:

- "Shedding of plant parts due to development of cork- like layer at their base" is known as abscission. ABA induces abscission by promoting the formation of abscission layer.

2) Dormancy:

- "Temporary suspension of growth & metabolism in any plant organ" $\xrightarrow{\text{is}}$ dormancy

- ABA induce dormancy in seeds & buds. During unfavorable conditions, ABA concentration increases in buds. Such buds remains dormant. When conditions becomes favourable, concentration of ABA decreases & dormant buds become active.
- ABA helps the plant to survive during unfavorable conditions.
- Seeds of some plants do not germinate immediately after harvesting due to high concentration of ABA. These germinate only when concentration of ABA decreases

3) Stomatal Closure:

- When sufficient amount of water is not present in plant, synthesis of ABA increases which accumulates in guard cells & induces stomatal closure. ABA reduces transpiration & conserve water in plant body

4) Formation of Perennating buds:

- Aquatic plant like lemna produce perennating buds when the ponds dry up. ABA promotes formation of perennating buds. Which survive during dry period. When water enters the pond, the buds becomes active

5) Senescence of Leaves:

- "Aging of plant parts is known as scenescene". It is due to breakdown of chlorophylls, RNA & proteins etc ABA promotes senescene of leaves by degrading chlorophyll.

ETHYLENE:

- It is a volatile gaseous growth regulator which promotes senescene & ripening of fruits
- R.Gane (1934) reported that ethylene is responsible for fruit ripening & can be considered as plant hormone. Ethylene is produced in almost all parts of the plant. It is synthesized from the amino acid called methenine.

Physiological functions:

- Ethylene affects fruit ripening & many aspects of plant growth & development---

1) Fruit Ripening:

- During fruit ripening, several degradative processes like loss of chlorophyll, increase in carotene & anthocyanin, hydrolysis of pectin etc., tales place as a result ofwhich fruits become soft & pulpy
  Ex: Banana, apple, tomato etc
  Hence ethylene is considered as fruit ripening harmones

2) Abscission:

- Ethylene promotes leaf abscission

3) Senescene:

- Ethylene promotes senescene of flower

4) Triple response growth:

- Ethylene inhibits the growth & longitudinal elongation of stem, stimulates its lateral growth (stem thickening) & cause transverse geotroplism. This peculaire pattern of growth is response growth

5) Flowering:

- Ethylene supress flowering in many plants however it stimulates flowering in pine apple.
- Some other important functions of ethylene are ----
- It promotes formation of adventitious roots
- It promotes formation of female flowers in cucurbita
- removes apical dominance

- helps in healing of wounds

ROLE OF PHYTOHORMONES IN AGRICULTURE & HORICULTURE:

- Phytohormones controles growth & development of plants in very low concentrations. They regulate the physiological processes like germination, flowering, organogenesis (morphogenesis), development of fruits etc. If Phytohormones are applied at critical stages of development growth can be promoted in desired direction & yield can be increased.
- Some important applications of growth regulators in agriculture & horticulture are

I. AUXINS: Several developmental responses are under the influence of auxins ----

1) Formation of roots on stem cuttings: Natural auxin like IAA & synthetic auxins like IBA, NAA etc are used to induce root formation on stem cutting when applied in low concentration. IBA is more effective in inducing root formation on stem cuttings. By treating the stem cuttings with Phytohormones, horticulturally important plants can be propagated rapidly
2) Prevention of Premature Fruit Fall: In fruit bearing trees like Mango, Orange, Citrus, Apple etc., premature fruit fall can be prevented by spraying synthetic auxins like IBA & NAA on leaves.
3) Herbicidal Activity: (Weed Killers): Synthetic auxins like 2, 4- D, & 2, 4, 5 – T are used as herbicides. They kill broad leaved dicotyledonous weeds. Because of selective action of 2, 4 –D, 2,4,5 – T are widely used to eradicate broad leaved dictolyledonous weeds in lawns, pasture land & cereal fields

- Applications of auxins increases the number of female flowers in cucurbita & enhances the fruit yield

II. GIBBERELLINS:

1) Application of gibberellins promotes the development of seedless fruits in grapes. It also increases the number of fruit branches per plant, the number of fruits per bunch & size of fruits. The sweetness of fruits may also increased.
   Application of gibberellins also promotes peduncle so that the fruits are apart from each other. Bunches with less tightly packed fruits are formed. Such bunches are less susceptable to fungal & insect attack
2) Ripened fruits may be damaged during storage & transport. If gibberellins are sprayed on plants before harvesting fruit ripening is delayed Gibberellins delay the formation of pigments in the rind & softening of tissue. Such fruits can with stand storage & trasportation
3) Application of gibberellins promotes formation of flowers in Roses, Rhododendron, and Poinsettia etc.
4) Application of gibberellins increase the yield & sucrose content in sugar cane
5) In Conifers, seed production can be increased by spraying a mixture of GA_4 & GA_7
6) Application of gibberellins enhances the germination of barley seeds. Germinating barely seeds are used in production of superior quality malt which is used in making beverages.

III. CYTOKININS:

2) Cytokinins enhances the shelf-life period of leafy vegetables such as lettuce & spinach [shelf –life period- storage period without loss of freshness] Foliar application of cytokinins before harvest keeps the leafy vegetables fresh for several days

3) Cytokinins enhances the vase-life period of flowers like Dianthus & Poinsettia. If the cut ends of pedicels are dipped in solution of Benzyl Amino Purine (BAP) the flowers do not wilt & remain fresh for several days in flower- vases

IV. ABSCISIC ACID: (ABA)

1) Potato tubers & Onion bulbs are stored, for longer periods as they are consumed throughout the year. In storage they sprout. Sprouting of tubers & bubs in storage can be delayed by preharvest foliar application of ABA on potato & onion crops.
2) ABA is used as antitranspiration to reduce rate of transpiration in crop plants

V. ETHYLENE: It is gaseous & volatile plant harmone & hence it is difficult to apply it is field. Ethephon is an ethylene – releasing substance & is widely used in agriculture & horticulture

1) Ethephone promotes the ripening of fruits like apple Banana, Watermelon etc
2) Ethephone induces flowering followed by the ripening of fruit in Pineapple
3) Ethephone promotes prolonged flow of latex in rubber plants
4) It improves the colour of berries of coffee
5) Application of ethephone on tobacco plant brings the simultaneous senescence of leaves. Ethephon treated leaves contains less nicotine content

Plant Physiology

Soil

1) The formation of soil is called
   1) Weathering 2) Transport of water 3) Pedogenesis 4) Erosion
2) Weathering is caused by
   1) Biological agents 2) Chemicals 3) Physical agents 4) 1, 2 & 3
3) True soil or solanum consists of
   1) Topsoil & Subsoil 2) Subsoils & parent rock
   3) Parent rock & regolith 4) regolith & Ahorizon
4) Biological activity is more due to microorganisms in
   1) Parent rock – Regoith 2) Sub-soil – Bhorizon
   3) Top-soil – A Horizon 4) Sub-soil – A Horizon
5) The roots of crop plants penetrate in to
   1) Sub soil 2) True soil 3) Top soil 4) Regolith
6) Humus is present in
   1) Sub soil 2) True soil 3) Regolith 4) Topsoil
7) Microbes are usually absent in
   1) regolith 2) topsoil 3) subsoil 4) solum
8) Natural aggregates of soil particles are called
   1) Clods 2) Peds 3) Sols 4) gels
9) Peds or clods constitute
   1) soil profile 2) soil organic matter 3) soil structure 4) soil atmosphere
10) Kaolin is a mineral constituent of
   1) slit 2) sand 3) gravel 4) clay
11) Good water holding capacity and poor aeration are seen in
   1) Sandy soils 2) Loamy soils 3) Sandy loams 4) Clayey soils
12) The root system in plants growing in clayey soils is damaged due to
   1) expansion of clayey soils when wet
   2) their negative charge
   3) their capacity to prevent leaching of cations

4) contraction when dry

13) This kind of soil is a good source of mineral nutrition for plants
1) Sandy soils 2) Clayey loams 3) Silty soils 4) Sandy loams

14) The best suited soil for the growth of plants is
1) Loamy soils 2) Clayey loams 3) Sandy loams 4) Sandy soils

15) The fleshly laid organic matter on earth's surface is called
1) Humus 2) Duff 3) Litter 4) Waste

16) Humus is formed due to the activity of
1) parasites 2) saprophytes 3) mineralization 4) humification (surface)

17) The partly decomposed organic matter on earth is called
1) litter 2) duff 3) humus 4) mineralization

18) The chemical decomposition of humus results in the formation of
1) Minerals 2) humus 3) Duff + litter 4) minerals + water

19) Water available to plants is
1) Runaway water 2) Gravitational water 3) Capillary water 4) Hygroscopic water

20) Chresard is equal to
1) Field capacity 2) Hollard 3) Echard 4) Capillary water

21) Hygroscopic water & capillary water constitute
1) Field capacity 2) Hollard 3) Echard 4) WSC

22) Aerenchyma and respiratory roots are an adaptation due to
1) less CO_2 in water 2) less O_2 in water
3) No CO_2 in water 4) No 'N' in water

23) Stable biological systems are formed in these soils
1) Sandy soil 2) Clayey soils 3) Loamy soil 4) Silty soils

24) Echard is
1) Hollard – chresard 2) PWP – WSC
3) Chesard – PWP 4) FC – gravitational water

25) Some soil bacteria and fungi secrete this phytohormone
1) NAA 2) IAA 3) BA 4) 2, 4 – D

26) Pedogenesis is by weathering and weathering is due to
A) Biological agencies B) Mechanical forces C) Chemical forces
1) A & C 2) B & C 3) A & B 4) ABC

27) Assertion: Sol is highly valuable
Reason: It takes 500 – 1000 years for the formation of 1 inch of top soil
1) A and R are true, R is the correct explanation of A
2) A and R are true, R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

28) Arrange the soil particles in decreasing order of diameter
A) Clay B) Slit C) Coarse sand D) Gravel
1) ABCD 2) DCBA 3) CDAB 4) ACDB

29) As the size of the soil particle increases
I) Water holding capacity decreases
II) Aeration increases
III) Water holding capacity increases
IV) Aeration decreases
1) I & II 2) II & IV 3) III & IV 4) I & IV

30) WSC = FC – PWP, this is also equal to
1) Holard – echard 2) Holard – chresard

3) Chresard – echard 4) Chresard + echard

31) Soil best suited for plant growth
1) sand 2) clay 3) loam 4) calcarious

32) Partly decomposed organic matter is called
1) humus 2) dough 3) litter 4) mor

33) Good soil is that which
a. allows only certain amount of water to enter
b. holds water that enters into it
c. permits water to trickle through it slowly
d. permits water to pass through it freely

34) Permanent wilting of a plant is due to
1) lack of water in the soil 2) lack of hygroscopic
3) lack of available water in the soil 4) all the above

35) The correct statement about soil is
a. the best soil for plant growth in loam soil
b. the water available for land plants is capillary water
c. soil water is inversely proportional to soil atmosphere
d. all the above

Keys

1) 3	2) 4	3) 1	4) 3	5) 3	6) 4
7) 1	8) 2	9) 3	10) 4	11) 4	12) 4
13) 2	14) 1	15) 3	16) 2	17) 2	18) 4
19) 3	20) 4	21) 1	22) 2	23) 3	24) 1
25) 2	26) 4	27) 1	28) 2	29) 1	30) 1
31) 3	32) 2	33) 3	34) 3	35) 4	

Absorption of Water

1) The Scientist who applied principles of thermodynamics to water potential are
1) Ledberg 2) Zinder 3) Slatyer & Taylor 4) Skoog

2) The difference between free energy of water in a system and pure water is
I) Osmotic potential II) Pressure potential
III) Chemical potential IV) Water potential
1) I & II 2) II & III 3) III & IV 4) II & IV

3) Water potential is measured by
1) Bars 2) Atmospheres 3) Mega pascals 4) 1, 2, 3

4) 1Mpa =
1) 10 bars 2) 100 bars 3) 0.981 atmospheres 4) 98.1 atmospheres

5) Osmotic potential is always Negative because
1) tugor pressure 2) wall pressure
3) increase in free energy 4) decrease in free energy

6) Matric potential of –300MPa is exhibited by
1) Wall pressure
2) turgose pressure or positive hydrostatic pressure tends to increase free energy
3) plant cells being open systems
4) colloidal substances are formed by hydrophilic substances

7) Random thermal motion of individual molecules in the direction of concentration gradient is
1) Filter paper 2) drywood 3) gelatin 4) 1, 2, 3
1) Osmosis 2) ψ 3) diffusion 4) imbibition
8) The substance with least imbibing capacity is
1) Osmosis 2) ψ 3) diffusion 4) imbibition
9) The substance with least imbibing capacity is
1) proteins 2) starch 3) cellulose 4) 1 or 2
10) Sleeping movements of leaves is due to
1) plasmolysis 2) osmosis 3) exosmosis 4) matric potential
11) Water cells enters the plant when it placed in
1) hypertonic solution 2) isotonic solution
3) hypotonic solution 4) imbibition
12) When a plant cell is placed in hypertonic, hypotonic and isotonic solutions respectively, the changes are
1) Plasmolysis, deplasmolysis, no change
2) No change, deplasmolysis and plasmolysis
3) Plasmolysis, no change, deplasmolysis
4) 2 or 3
13) Plasmolysis is natural in
I) Extreeme stress II) Saline conditions
III) Hypotonic solutions IV) Isotonic solutions
1) I & II 2) II & III 3) III & IV 4) II, IV
14) Pickles and jams are
1) Hypotonic 2) Isotonic 3) Hypertonic 4) with $\psi = 0$
15) The absorption of water by plants is
1) active 2) passive 3) active or passive 4) first passive later active
16) Most of the water absorbed by plants is through
1) Osmosis & passive 2) Diffusion & active
3) Osmosis & active 4) Imbibition & passive
17) Net movement of water is zero between root hair and soil solution is when
1) Protoplasm is hypotonic to soil solution
2) One is hypertonic
3) Both are isotonic
4) One is hype and other is hypertonic
18) When the ψw of a cell is equal to $\psi\pi$, the cell is undergone
1) endosmosis 2) deplasmolysis 3) plassmolysis 4) diffusion
19) The water potential in tall trees is
1) 1.3Mpa 2) 2Ma 3) 4Mpa 4) 10Mpa
20) Cohesion –tension theory was proposed by
1) Slatyer 2) Tailer 3) Dixon 4) Murashige
21) The upward movement of water in plants is called
1) guttation 2) osmosis 3) ascent of sap 4) diffusion
22) Wet sponge experiment is a model for
1) osmosis 2) plassmosis 3) ascent of sap 4) guttation
23) Tensions build up in xylem due to
1) photosynthesis 2) transpiration 3) plasmolysis 4) deplasmolysis
24) The water column moving upward is unbroken due to
1) cohesion of H_2O 2) adhesion of H_2O 3) transpirational pull 4) 1, 2, 3

25) 1.3Mpa water potential difference can raise water column up to a height of
1) 400mts 2) 400feet 3) 200feet 4) 40feet

Keys

1) 3	2) 3	3) 4	4) 1	5) 4
6) 2	7) 4	8) 3	9) 3	10) 2
11) 3	12) 1	13) 1	14) 3	15) 2
16) 1	17) 3	18) 3	19) 3	20) 3
21) 3	22) 3	23) 2	24) 4	25) 2

Transpiration

1) SPAC is established by
1) Plants 2) Soil 3) atmosphere 4) 1, 2, 3
2) The % of water absorbed by plants used for metabolic activities is
1) 95% 2) 90% 3) 85% 4) 5%
3) Transpiration is similar to
1) Osmosis 2) Plasmolysis 3) Evaporation 4) Guttation
4) Transpiration is a biological activity involving the physical process of
1) guttation 2) inbibition 3) evaporation 4) exosmosis
5) Stomatal transpiration accounts for
1) 1- 2% 2) 5 –10% 3) 25 –50% 4) 80 –95%
6) The kind of transpiration loss is seen only in perennial woody plants (of dicots)
1) Stomatal 2) Lenticular 3) Cuticular 4) 1 or 3
7) The leaf area covered by stomata is
1) 5 –10% 2) 10 –25% 3) 1-2%4) 16-32%
8) Dumbell cells with chloroplasts are
1) Dicots 2) Gymnosperms 3) Monocots 4) Bryophytes
9) Epidermal cells with chloroplasts are
1) subsidiary cells 2) accessory cells
3) guard cells 4) stomatal cells
10) The turgovre operated value of the plant leaf is
1) stomata 2) lenticels 3) cuticle 4) hydathodes
11) The stomata in succulents is
1) photo active 2) scotoactive 3) 1 or 3 4) 1 and 2
12) When the guard cells are turgid, the stomata is
1) fully closed 2) partly closed 3) open 4) 1 or 3
13) The ion that accumilates in stomata when exposed to light is
1) Na^+ 2) Ca^+ 3) Mg^{2+} 4) K^+
14) The entry of Cl^- ions into the guard cells is due to
1) Electric charge 2) Active transport
3) By spending ATP 4) 2 & 3
15) When K^+ and Cl^- ions enter the guard cells, their water potential becomes
1) zero 2) increased 3) decreased 4) remains same
16) The H^- donor in guard cells is
1) Malate 2) Mallic acid 3) KOH4) NaC*l*
17) The entry of K^+ ions into guard cells is
I) active process II) against concentration gradient

III) passive process IV) diffusion
1) I & II 2) II & III 3) II & IV 4) I & IV

18) The organic acid commonly produced from starch in guardcells during day time is
1) Citric acid 2) Mallic acid 3) Iso citric acid 4) Aspartic acid

19) The balancing ion for malate ion in guard cells is
1) Cl^- 2) H^+ 3) K^+ 4) Na^+

20) The fate of malate during right is
I) Consumption in TCA right is II) Transport to adjoining cells
III) Formation of malic acid IV) Formation of starch
1) I & II 2) II & III 3) III & IV 4) I & III

21) The effect of light on transpiration is
1) 2 fold 2) 3 fold 3) 4 fold 4) many fold

22) This is not directly proportion (environmental factor and transpiration)
1) light 2) humidity 3) wind 4) temperature

23) Assertion: Transpiration is biological evaporation
Reason: Loss of water in the form of water vapour through aerial parts is transpiration
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

24) Assertion: Stomatal transpiration accounts for 80 –95% of total transpiration
Reason: Stomata are present on leaves young stems, flowers and fruits
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

25) Assertion: Lenticular transpiration occurs for 1 – 2% in herbs
Reason: Secondary growth is absent in herbs and annuals
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

26) Assertion: Stomata are turgor volves
Reason: Differential thickenings of guard cells make them act like valves
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

27) Assertion: The entry of ions into guard cells is completely by active transport
Reason: C*l* enters the guard cell passively to balance the charge
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

28) Assertion: In succulent xerophytes stomata are scoto active
Reason: The proton pump is closed at right in scotoactive plants
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false

4) A is false but R is true

Keys

1) 4	2) 4	3) 3	4) 3	5) 4
6) 2	7) 3	8) 3	9) 3	10) 1
11) 2	12) 3	13) 4	14) 1	15) 3
16) 2	17) 1	18) 2	19) 3	20) 1
21) 2	22) 2	23) 1	24) 1	25) 4
26) 1	27) 4	28) 3		

Water Relations of Plants

Ex –2

1) Osmotic potential of plant cells indicates
   a. The degree of dehydration of Protoplasm
   b. The degree of hydration of Protoplasm
   c. The decrease of Turgor pressure
   d. The decrease of wall pressure
2) Cell A has ψ = -0.3Mpa, cell B has ψ = -0.2Mpa and cell C has ψ = -0.7Mpa. Then water diffuses from
   1) A to B to C 2) A to C to B 3) B to A to C 4) C to B to A
3) A turgid cell get plasmolysed, when placed in a
   1) Hypertonic solution 2) Hypotonic solution
   3) Isotonic solution 4) Pure water
4) Bacteria and fungal spores are killed when they enter into pickles and jams due to
   1) Plasmolysis 2) Endosmosis
   3) Deplasmolysis 4) Presence of poisonous minerals
5) Correct expression to find out the value of the water potential of a closed system is
   1) $\psi = \pi + P + T$ 2) $T = \psi + \pi - P$ 3) $\pi = \psi + P - T$ 4) $\psi + \pi + T$
6) When soaked in water why the proteinaecous pea seeds swell up more than the starchy wheat grains?
   a. Inbibition capacity of proteins is more than that of starch
   b. Presence of more hydrophilic colloids in wheat grains
   c. Cell membranes of pea seeds is more permeable
   d. Cell walls of wheat grains are less permeable
7) Dry Wooden pegs are hammered into the crevices of rocks and soaked in water to extended the splittings. The physical phenomenon involved is
   1) Diffusion 2) Imbibition 3) Osmosis 4) Bulk flow
8) The reason for the formation of water column in xylem elements during transpiration is
   a. Cohesive forces of water molecules
   b. Adhesive forces of water molecules
   c. Both Cohesive and Adhesive forces of water molecules
   d. Turgor pressure forces
9) Scoto active stomata are present in
   1) Mesophytes 2) Hydrophytes 3) Xerophytes 4) Active absorption

10) Cohesion theory is based on
1) Root pressure 2) Turgor pressure 3) Transpiration pull 4) None of the above

11) What would be present in between plasma membrane and cell wall in a plasmolysed cell
1) Hypertonic solution 2) Hypotonic solution 3) Isotonic solution 4) Vacuum

12) Guttation is due to
1) Osmotic pressure 2) Turgor pressure 3) Root pressure 4) None

13) Dixon proposed
1) Root pressure theory 2) Cohesion – Tension theory
3) Osmotic theory 4) None

14) Presence of K^+, Cl^- and malate in guard cells shows
1) Water potential decreases 2) Water potential increases
3) Osmotic potential decreases 4) Wall pressure increases

15) ATP utilisation is associated with
a. Influx of K^+ ions into the guard cells and efflux of H^+ ions into the surrounding epidermal cells
b. Break down of starch in the guard cells
c. To control photosporylation
d. Influx of H^+ ions into the guard cells

16) The water holding capacity of the soil depends on
a. Amount of inorganic material
b. Size of its particles
c. The nature of original rock from which soil particles are formed
d. The extent of microbial activity in the soil

17) Percentage of water of soil when a plant wilts is called
1) Turgidity 2) Wilting coefficient
3) Field capacity 4) Water retaining power of soil

18) Selective permeability is identified with
1) Diffusion 2) Osmosis 3) Imbibition 4) Plasmolysis

19) Protoplasm shrinks and recedes from the cell wall during
1) Imbibition 2) Absorption 3) Osmosis 4) Plasmolysis

20) Embolism is refers to as red
a. Obstruction to the continuity of water column in xylem as a result of formation of air bubbles
b. Continuity of water column in xylem
c. Cohesion and adhesion of water molecules during ascent of sap
d. Upward movement of water from roots to shoot against gravitational force

21) Transpiration from plant will be more rapid when
a. Atmosphere is saturated with water
b. There is excess of water in soil
c. Air is still
d. Environmental conditions are dry

22) Due to the entry of K^+ and Cl^- and high malate levels in guard cells which of the following does not occur?
1) Cell sap concentration increases 2) Water potential decreases
3) Wall pressure decreases 4) Endosmosis is favoured

23) High rate of transpiration is found in plants growing
1) At sea level 2) On small hills
3) On mountains of high altitude 4) On other trees

24) Root – Shoot ratio is more in
1) Ficus 2) Mangifera 3) Sorghum 4) Maize
25) Leaf of which of the following plant wilts earlier?
1) Nerium 2) Calotropis 3) Bryophyllum 4) Hibiscus
26) Hormone synthesized in guard cells particularly under water stress condition is
1) AAB 2) IAA 3) Zeatin 4) ABA
27) ABA acts as antitranspirant by
a. Lowering the vapour pressure gradient
b. Increasing the K^+ level in guard cells
c. Decreasing the root – shoot ratio
d. Inducing stomatal closure
28) Assertion: Region of root is mostly responsible for the absorption of water in plants
Reason: Absorption of water is mostly carried out by active process
a. A and R are true and R is the correct explanation of A
b. A and R are true and R is not the correct explanation of A
c. A is true but R is false
d. A is false but R is true
29) Assertion: Cell or tissue shrinks when kept in hypotonic solution
Reason: Plasma membrane can be studied in a plasmoysed cell
a. A and R are true and R is the correct explanation of A
b. A and R are true and R is not the correct explanation of A
c. A is true but R is false
d. A is false but R is true
30) Assertion: In the process of osmosis water moves from lower concentrated solution to higher concentrated solution across the selectively permeable membrane
Reason: At equilibrium no net movement of water will be observed in the process of osmosis
a. A and R are true and R is the correct explanation of A
b. A and R are true and R is not the correct explanation of A
c. A is true but R is false
d. A is false but R is true
31) Assertion: Dry seeds swell up due to imbibition during seed germination
Reason: The first physical change during seed germination in increase in volume of seeds
a. A and R are true and R is the correct explanation of A
b. A and R are true and R is not the correct explanation of A
c. A is true but R is false
d. A is false but R is true
32) Assertion: Main force responsible for ascent of sap is transpiration pull
Reason: Formation of air bubbles in xylem elements leads to embolism
a. A and R are true and R is the correct explanation of A
b. A and R are true and R is not the correct explanation of A
c. A is true but R is false
d. A is false but R is true
33) Assertion: Rate of transpiration would be more in Maize than in Sorghum
Reason: In plants rate of transpiration will be directly proportional to the altitude of the place
a. A and R are true and R is the correct explanation of A
b. A and R are true and R is not the correct explanation of A
c. A is true but R is false
d. A is false but R is true

34) Assertion: In Bryophyllum, guard cells become turgid during night time
Reason: In the guard cells of grass leaves p^H value would be high during day time
  a. A and R are true and R is the correct explanation of A
  b. A and R are true and R is not the correct explanation of A
  c. A is true but R is false
  d. A is false but R is true

35) Assertion: Rate of transpiration would be very high in large trees
Reason: Rate of foliar transpiration would be more in herbs
  a. A and R are true and R is the correct explanation of A
  b. A and R are true and R is not the correct explanation of A
  c. A is true but R is false
  d. A is false but R is true

36) The rate of transpiration increases with
  a. Increase of temperature in the atmosphere
  b. Increase in the concentration of CO_2 in the atmosphere
  c. Increase in the O_2 concentration in the atmosphere
  d. High humidity in the atmosphere

37) A cell is kept in a hypertonic solution undergoes
1) Plassmolysis 2) Osmosis 3) Transpiration 4) Imbibition

38) Pickles are dried by addition of salt because
  a. Salt is poisonous to micro organisms
  b. Salt eliminates water from cells
  c. Salt forms a layer to prevent entry of organisms
  d. Salt helps in activity of bacteria

39) The amount of water that remains in soil after the water has been allowed to drain away is
1) Field capacity 2) Ground water
3) Total water 4) Permanent wilting percentage

40) The technique of growing plants in water culture is called
1) Ikebana 2) Hydroponics 3) Tissue culture 4) Cell culture

Keys

1) 2	2) 3	3) 1	4) 1	5) 1
6) 1	7) 2	8) 3	9) 4	10) 3
11) 1	12) 3	13) 2	14) 1	15) 1
16) 2	17) 2	18) 2	19) 4	20) 1
21) 4	22) 2	23) 3	24) 3	25) 4
26) 4	27) 4	28) 3	29) 4	30) 1
31) 1	32) 1	33) 2	34) 2	35) 4
36) 1	37) 1	38) 2	39) 1	40) 2

Mineral Nutrition
Multiple Choice Questions

1) The importance of soil in plant nutrition was first established experimentally by
1) J.Sachs 2) John Woodward 3) J.B.Helmont 4) De Saussure

2) Essential elements required for plant growth can be established by
1) Giger Muller Counter 2) Autoradiography
3) Hydroponics 4) Ash analysis

3) Arnon and stout proposed

1) Importance of soil 2) Law of limiting factors
3) Active absorption mechanisms 4) Criteria for essentiality of elements

4) One of the following is not a criteria for determining the essentiality of an element
   a. The element is directly required in vegetative and reproductive stages of the plant
   b. The element is distributed in all parts of the plant equally
   c. The deficiency symptoms of an element expressed by the plant can be removed by adding only the same
   d. The element – role in the plant nutrition is direct

5) Total number of essential elements required by plants are
   1) 15 2) 13 3) 16 4) 20

6) One of the following is not a trace element
   1) B 2) Zn 3) Cu 4) Co

7) Chlorosis yellowing followed by purpling in the petioles of old leaves and stems appear due to the deficiency of
   1) N 2) P 3) K 4) S

8) A tree element in that which is
   1) Traced by Geiger Muller counter 2) Required in very minute counter
   3) Draws other elements out of protoplasm 4) Discovered first in a cell

9) Which of the following one are macronutrients
   1) Mg & Fe 2) Fe & Zn 3) Zn & Ca 4) Ca & P

10) Non-metabolic type of oin absorption explains
   a. The movement of mineral ions from soil solution to apoplast
   b. The movement of ions from inner space to outer space against concentration gradient
   c. The movement ions from outer space to inner space across the membrane
   d. The transport of minerals from leaves to root system

11) Membrane protein carries responsible for the transfer of ions from outside to inside or inside to outside are called
   1) Co-transporters 2) Uniproters 3) Symporters 4) Antiporters

12) An event of active transport of ions, responsible for the uptake of essential ions and release of non-essential ions, is called
   1) Passive transport 2) Primary active transport
   3) Secondary active transport 4) Non-metallic transport

13) 'Bacterization' deals with
   a. The hatching of bacteria on suitable nutrient media
   b. The seed dressing with symbiotic bacteria
   c. The seed treatment with biospesticides
   d. The control of endo-pathogenic bacteria of plants

14) Rhizobium inoculants are applied to the seeds with
   1) Benzyl sulphate 2) Mercuric chloride
   3) Gum or carboxy methyl- cellulose 4) 2, 4, 5 – T

15) One of the following acts as endosymbiont in maize, sorghum etc. in cortical cells and protoxylem vessels
   1) Anabaena 2) Azotobacter 3) Azospirillum 4) Clostridium

16) VAM fungi increases
   1) Phosphate absorption 2) Potassium absorption
   3) Nitrogen absorption 4) Both Phosphate & Nitrogen absorption

17) Element required in the synthesis of middle lamellum is
   1) K 2) Ca 3) P 4) Mg

18) Active ion absorption requires ATP as it

1) According to concentration gradient 2) Against concentration gradient
3) Only in saline conditions 4) During meristematic growth

19) Membrane protein carriers involved in the unidirectional transport of two types of ions are called
1) Symporters 2) Co-enzymes 3) Cytochromes 4) Phospholipids

20) Protein carries responsible for the inward movement of H^+ associated with outward movement of Na^+ are called
1) Sympoters 2) Antiporters 3) Uniporters 4) Phytochromes

21) Mg^{2+} is required for the synthesis of
a. Fatty acids and amino acids
b. Chlorophyll and Ribosomes (Binding factor)
c. Cytochromes and Ferridoxin
d. TPP & FAD

22) The protein components of 'nitrogenase' contains
1) Mg & Mo 2) Fe & Mo 3) Fe & Cu 4) Mg & Fe

23) Both Nitrogen and Phosphorous are the structural components of
1) Nucleic acids 2) Cells membranes 3) NADP 4) All

24) Identify the correct match
a. Entry of ions into outer space – passively by carriers
b. Exit of ions form the outer space – Actively, directly by diffusion
c. Entry of ions into inner space through the membrane – by carriers
d. Entry of ions into membrane – according to potential gradient

25) Accumulation of K^+ ions in the cells of Nitella against concentration gradient is possible at the expense of
1) Kinetic energy 2) Metabolic energy 3) Gradient 4) External force

26) Azolla is useful as biofertilizer in rich fields mainly by virtue of its
1) Symbiosis with Nostoc 2) Ability to live in water
3) Symbiosis with Anabeana azollae 4) Ability to produce Nitrogenase

27) VAM is used as biofertilizer because it
1) Fixes phosphorous 2) Assimilates phosphorous
3) Increase phosphate absorption by roots 4) Release phosphorous into soil

28) Water fern useful as biofertilizer in rice fields is
1) Aulosoira 2) Anabaena 3) Azolla 4) Salvinia

29) Hydroponics indicate
1) Elements found in plants body 2) Elements absorbed by plants
3) Elements essential to plant body 4) Elements transported through phloem

30) Assertion: "Criteria of essentiality" was proposed by Arnon and Stout
Reason: All the elements present in plant body are not essential elements
a. A and R are true and R is the correct explanation of A
b. A and R are true and R is not the correct explanation of A
c. A is true but R is false
d. A is false but R is true

31) Assertion: Entry of ions from soil solution to outer space does not require utilization of energy
Reason: Ion carriers present in the plasmembrane are responsible for active uptake of ions
a. A and R are true and R is the correct explanation of A
b. A and R are true and R is not the correct explanation of A
c. A is true but R is false

d. A is false but R is true

32) Assertion: Rhizobium inoculants are not useful for rice crop
Reason: Azospirillum is an endosymbiont found in the roots of rice plants
a. A and R are true and R is the correct explanation of A
b. A and R are true and R is not the correct explanation of A
c. A is true but R is false
d. A is false but R is true

33) Assertion: Azolla is used as biofertilizer in rice fields
Reason: Anabena is the endosymbiont in the leaves of Azolla
a. A and R are true and R is the correct explanation of A
b. A and R are true and R is not the correct explanation of A
c. A is true but R is false
d. A is false but R is true

34) In hydrophonics plants are grown in
1) pure water 2) Water + inorganic salts
3) Water + organic substances 4) Water + air

35) Some of the essential elements were discovered by
I) Sachs & Knops II) Arnon & Perry stout
III) Hydrophonics IV) In Aerophonics
1) I & II 2) II & III 3) I & III 4) II & IV

36) Criteria of essentiality was proposed by
1) Knops & Sachs 2) Daniel Arnon & Perry Stout
3) Slatyer & Taylor 4) Benson & Bassham

37) The number of major elements is
1) 10 2) 11 3) 9 4) 8

38) The number of trace elements is
1) 10 2) 8 3) 7 4) 6

39) Alga used in active absorption experiments is
1) Chlorella 2) Nitella 3) Scenedesmus 4) Spirulina

40) Respiratory inhibitors are
1) $CaCl_2$ & $NaCl$ 2) Azides & Cyanides
3) Oxalates & Suphates 4) Cupric & Mercuric Compound

41) Ion transport is carried out by
1) permeable cellwall 2) entire plasma membrane
3) carrier proteins 4) uniporters only

42) ATP is spent during this phase of ion transport
1) secondary active transport 2) co – transport
3) symport or antiport 4) primary active transport

43) Actual ion transport is carried out during
1) Primary active transport 2) Secondary active transport
3) ATP – ase 4) H + ATP –ase

44) This is always uniport
1) secondary active transport 2) symport
3) antiport 4) primary active transport

45) An example for uniporter is
1) H^+ - NO_3^- 2) H^+ - Cl^- 3) H^+ - PO_4^- 4) Na^+ - ATPase

46) Two ions move in opposite directions is called
1) co-transport, symport 2) co-transport – antiport
3) counter transport, symport 4) co-transport

47) Secondary active transport is carried due to
1) Proton motive force 2) Exodus of protons 3) ATP 4) Elasticity

48) Carboxy methyl cellulose is a
1) gum used in bacterization 2) gum used in algalization
3) anti transpirant 4) anti-bacterial substance

49) The free living Nitrogen fixing bacterium is
1) Azospirillium 2) Azatobacter 3) Rhizobium 4) Azolla

50) An associate symbiont is
1) Azatobacter 2) Azospirillum 3) Rhizobium 4) Anabaena

51) N-fixing prokaryote used in Sorghum and pearl millet crops is
1) Azospirillum 2) Azatobacter 3) Azolla 4) Nostoc

52) Seed dressing with bacteria is
1) algalization 2) bacterization
3) mycorhizaal association 4) prokaryotization

53) Organisms that can fix Nitrogen in free living conditions and as symbionts are
1) Azolla, Azospirillum 2) Nostoc, Anabaena
3) Azolla, Nostoc 4) Rhizobium, Azolla

54) Venkatraman coined the term
1) Bacterization 2) Algalization 3) Detoxification 4) Photo oxidation

55) Azolla fixes atmospheric nitrogen because
a. it has that enzyme
b. it has Rhizobium inside its
c. it has Anabaena azollae as endosymbiont in its leaves
d. it has Azospirillumas associated symbiont

56) Heavy metal tolerance is shown by
1) Nostoc 2) Rhizobium 3) Glomus 4) Azolla

57) Fungal association with roots of higher plants is
I) Ectomycorrhiza II) Endomycorrhiza III) Ecotendomycorrhiza
1) I alone 2) II alone 3) II & III only 4) I, II & III

58) Endotropic mycorrhiza always produce
1) Vesicles & arbuscules 2) Vesicules only
3) Arbuscules 4) Vesicles or arbuscules

59) Glomus is
1) AM fungi 2) VAM fungi 3) Ectotropic 4) Parasite

60) AM fungi increases absorption of
1) NO_3^- 2) P 3) Ca 4) Mg

Keys

1) 2	2) 3	3) 4	4) 2	5) 3	6) 4	7) 1	8) 2	9) 2
10) 1	11) 4	12) 4	13) 2	14) 3	15) 3	16) 1	17) 2	18) 2
19) 1	20) 2	21) 2	22) 2	23) 4	24) 3	25) 2	26) 3	27) 3
28) 3	29) 3	30) 1	31) 2	32) 3	33) 1	34) 2	35) 3	36) 2
37) 3	38) 4	39) 2	40) 2	41) 3	42) 4	43) 2	44) 4	45) 4
46) 2	47) 1	48) 1	49) 2	50) 2	51) 1	52) 2	53) 2	54) 2
55) 3	56) 4	57) 4	58) 3	59) 1	60) 2			

Enzymes

1) An Enzyme is a protein with catalytic property, was stated by
1) Louis Pasteur 2) Dixon and Web 3) Haldane 4) Northrop
2) Pepsin and Trypsin were crystalized by
1) John Northrop 2) Haldane 3) James sumner 4) David Phillips
3) One of the following statements is wrong
   1) Enzymes are inactive in small concentrations
   2) All enzymes are not made up of proteins
   3) Molecular weight varies from one enzymes to another
   4) Enzymes will not affect the equilibrium of the reaction
4) Enzyme main role is
   1) To increase the activation energy of the reaction
   2) To lower the activation energy of the reaction
   3) Activation energy of the reaction shall not change
   4) No effect on the energy of activation of the reaction
5) Apoenzyme is
1) Non protein part of an enzyme 2) Protein part of an enzyme
3) Partly protein and partly non protein 4) Polysaccharide
6) Haem moiety of peroxidase is a
1) Apoenzyme 2) Co-enzyme 3) Metal ion cofactor 4) Prosthetic group
7) A simple enzyme contains
1) Apoenzyme and Metallic ion 2) Apoenzyme and Co-enzyme
3) Apoenzyme and Prosthetic group 4) Only protein part
8) The enzyme ‘hexokinase’ comes under the group
1) Oxidoreductase2) Transferases 3) Peptidases 4) Lyases
9) The group of enzymes involved in the rearrangement of atoms of a molecule are
1) Lyases 2) Isomerases 3) Ligases 4) Transferases
10) Assertion: Proteinaceous nature of enzymes was first suggested by Northrop and associates
Reason: All enzymes are proteins but all proteins are not enzymes
   1) A and R are true and R is the correct explanation of A
   2) A and R are true and R is not the correct explanation of A
   3) A is true but R is false
   4) A is false but R is true
11) Assertion: Prosthetic group is an organic substance which is tightly bound to apoenzyme
Reason: Apoenzyme alone may carryout biochemical reaction in the absence of co-factor
   1) A and R are true and R is the correct explanation of A
   2) A and R are true and R is not the correct explanation of A
   3) A is true but R is false
   4) A is false but R is true
12) Assertion: Ligases can not carry out biochemical reactions in the absence of ATP
Reason: They synthesize new bonds between substrate molecules
   1) A and R are true and R is the correct explanation of A
   2) A and R are true and R is not the correct explanation of A
   3) A is true but R is false
   4) A is false but R is true
13) Assertion: Fourth number of enzyme code does not specify any information regarding catalysis of the enzyme
Reason: Enzyme code of glucose 6-phosphotransferase is 2.1.7.2

1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

14) Haem moiety of peroxidase is a typical example of
1) Inhibitor 2) Activator 3) Prosthetic group 4) Apoenzyme
15) J.B.S. Haldane
1) Isolated enzymes in pure form 2) Determined amino acids sequence of urease
3) Published a treatise on enzymes 4) Elucidated x-ray structure of lysozyme
16) Mn^{2+} is a medal ion co-factor in the enzyme
1) Pyruvic kinase 2) PEP carboxy kinase
3) Carbonic anhydrase 4) Catalase
17) Cell free enzymes of yeasts which ferment the sugar are
1) Proenzymes 2) Anoenzymes 3) Zymogens 4) Zymase
18) Protein nature of enzymes was first established by
1) James Boner 2) John Northrop 3) James Sumner 4) Haldane
19) Metal ion activator of PEP carboxy kinase is
1) Mg^{++} 2) Zn^{++} 3) Fe^{++} 4) Mn^{++}
20) Cytochrome oxidase contains
1) Fe 2) Mg 3) CO 4) Hg
21) Enzymes are sensitive to
1) Rainfall 2) Light 3) Change of p^H 4) Wind velocity
22) Trypsin is an enzyme which changes
1) Polysaccharides into disaccharides 2) Peptides into amino acids
3) Peptones into peoptides 4) Sucrose into glucose
23) A non-protein organic part of attached firmly by a covalent linkage to the apoenzyme is called
1) Coenzyme 2) Prosthetic group 3) Activator 4) Cofactor
24) Hydrolytic enzymes which act on low p^H are called
1) Proteases 2) Amylases 3) Hydrolases 4) Peroxidases
25) Enzymes involved in a chemical reaction
1) Are destroyed after the reaction 2) Are consumed during the reaction
3) Reduce activation energy 4) Increase activation energy
26) The protein nature of enzymes was established by
1) Buchner 2) Sumner 3) Northrop 4) Haldane
27) The protein nature of enzymes was proved by
1) Sumner 2) Bychner 3) Haldane 4) Northrope
28) The first cell free enzyme studied was
1) Urease 2) Cytase 3) Zymate 4) Trypsin
29) Enzymes
I) Biocatalysts II) Hasten reaction
III) Charge equilibrium IV) Remain unchanged during reaction
1) I, II, III 2) II & III, IV 3) III, IV 4) Except III all are correct
30) The holoenzyme consists of
1) only protein 2) protein + cofactor
3) protein + metal only 4) protein + prothetic group only
31) Chemical analysis of catalyse yields
I) aoenzyme II) Fe^{2+} III) Mg^{2+} IV) Zn^{+}
1) I+II 2) I + III 3) I +IV 4) I + II + III

32) Organic molecules loosely associated with apoenzymes are
1) metal ion co-factors 2) protheticgroups
3) co-enzymes 4) simple enzyme
33) Prothetic groups
1) tightly bound to apoenzymes 2) loosely associated with apoenzyme
3) moity loosely held by apoenzyme 4) can be easily separated from apoenzymes
34) The most important property of enzyme is
1) protein nature 2) active in minute quantity 3) specificity 4) thermolabile
35) TON represents
1) specificity of enzymes 2) activity of enzymes
3) p^H sensitivity of enzymes 4) thermolabile nature of enzymes
36) The optimum temperature for many enzymes is
1) 10-15^{0}C 2) 40 –50^{0}C 3) 25 –30^{0}C 4) 20 – 50^{0}C
37) An example for desmolysing enzymes
1) Prot eases 2) Esterases 3) Amidases 4) Aldolase
38) Reduction of H_2O_2 by liberating O_2 is catalysed by
1) Catalase 2) Peroxidases 3) Carboxylases 4) Hydases
39) Phosphoglyceromutase is an example for
1) Transaminase 2) Carboxylase 3) Aldolase 4) Iso-merase
40) The first class of enzymes in the classification by enzyme commission of IUB is
1) Hydrolases 2) Transaminase 3) Oxidoreductase 4) Kinases
41) NAD^+, FAD^+ are always involved in
1) Phosphate transfer 2) Breaking of peptide bonds
3) Transamination 4) Dehydrogenation
42) The common action catalysed by phosphotases & peptidases is
1) addition of phosphate group 2) cleavage by hydrolysis
3) group transfer 4) cosynthesis of new bonds by hydrolysis of ATP
43) Substrates are broken down without adding water by
1) ligases 2) lyases 3) oxidases 4) reductases
44) New bonds are formed by using energy liberated in hydrolysis of ATP by
1) kinases2) phosphotases 3) phosphotransferases 4) synthetases
45) Isolated DNA and vector DNA are joined by
1) ligases 2) lyases 3) hydrolases 4) amidases
46) In E.C. 2.7.1.2, the ‘7’ stands for
1) Class 2) Subclass 3) Sub-classes 4) Serial number
47) Transfer of hydrogen to O_2 is done by
1) oxidases 2) dehydragenases 3) kinases 4) lyases
48) Rearrangement of atoms is catalysed by
1) synthetases 2) lyases 3) ligases 4) isomerases
49) Enzymes are defined as proteins with catalytic properties due to their power of specific activation by
1) Dixon & W.feb2) Louis Pasteur
3) Edward Jenner 4) Edward Buchner
50) The first cell free enzyme and scientist who identified it were
1) Zymase & Sumner 2) Louis Pasteur
3) Frease & Sumner 4) Pepsin & Northrop

Keys

1) 2	2) 1	3) 2	4) 2	5) 2	6) 4	7) 4	8) 2	9) 2
10) 4	11) 3	12) 1	13) 3	14) 3	15) 3	16) 2	17) 4	18) 3
19) 4	20) 1	21) 3	22) 2	23) 2	24) 4	25) 3	26) 2	27) 4
28) 3	29) 4	30) 2	31) 1	32) 3	33) 1	34) 3	35) 2	36) 3
37) 4	38) 1	39) 4	40) 3	41) 4	42) 2	43) 2	44) 4	45) 1
46) 2	47) 1	48) 4	49) 1	50) 2				

Photosynthesis

Ex –1

1) All enzymes are made up of
   1) Carbohydrates 2) Lipids
   3) Amino acids 4) Mineral elements
2) Indicate the correct statement
   1) Vitamins are food stuffs
   2) Absorption and surface tension are synonymous
   3) Carbohydrates are invariably the respiratory substrates
   4) Proteins build protoplasm
3) Chlorophyll is not formed in the absence of the following trance elements
   1) Cellulose2) Starch 3) Calcium 4) Iron
4) Green plants manufacture
   1) Sugar, fats, starch and proteins 2) Sugar only
   3) Sugar and starch 4) Sugar, starch and fats
5) Light energy is converted into chemical energy, during
   1) Assimilation 2) Photolysis 3) Fermentaion 4) Photosynthesis
6) The chemical energy synthesised during photosynthesis in the form of
   1) ADP 2) ATP 3) DNA4) Nucleotides
7) When ATP is converted to ADP, it releases
   1) Electricity 2) Hormones 3) Enzymes 4) Energy
8) Intensity of carbon assimilation is great in
   1) Bright light 2) Green light 3) Blue light 4) Red light
9) Out of the following which enters into the composition of chlorophyll
   1) Calcium 2) Iron 3) Magnesium 4) Molybdenum
10) Carbondioxide in the atmosphere remains relatively constant because
    1) CO_2 is converted into carbohydrates during photosynthesis
    2) CO_2 is converted to calcium carbonate
    3) Bacteria use up carbon-dioxide
    4) CO_2 is released during respiration and absorbed in photosynthesis
11) Enzymes are made up of
    1) Carbohydrates 2) Fats 3) Proteins 4) DNA
12) In the light phase of photosynthesis, green plants release
    1) Oxygen 2) Nitrogen 3) Sulphur dioxide 4) Carbon dioxide
13) A carbohydrate that does not require further digestion in plant cell is
    1) Glucose 2) Starch 3) Sucrose 4) Cellulose
14) Chlorophyll is not formed in the absence of the following trace elements
    1) Iron 2) Magnesium 3) Calcium 4) Potassium

15) The most unique feature of photosynthesis is
1) Production of carbohydrates
2) Production of oxygen
3) Conversion of light energy into chemical energy
4) All the above

16) The chief photosynthetic pigment in red algae is
1) Xanthophyll 2) Phycoerythrin
3) Chlorophyll 4) Fucoxanthin

17) Which of the following is directly affected by light?
1) Flowering 2) Emergence of radicle
3) Food manufacture 4) Embryo formation

18) Enzymes are present in the plant body
1) Only in leaves 2) Only in storage organs
3) In all living cells 4) Only in flowers

19) Which of the following statements is correct?
1) Plants carry on photosynthesis during the day and respire all the time
2) Plants carry on photosynthesis during the night and respiration during the day
3) Plants carry on photosynthesis all the time
4) None

20) The yellow and orange colour of petals and fruits is due to
1) Chloroplasts 2) Chromoplasts
3) Leucoplasts 4) Anthocyanin

21) The most effective colour of visible light spectrum for photosynthesis is
1) Blue light 2) Red light 3) Orange light 4) Green light

22) Scientist who proposed Mass flow hypothesis is
1) De vries 2) Munch 3) Sachs 4) J.C.Bose

23) Which two type-functions given in a group below are not alike?
a) Photosynthesis – protein synthesis
b) Cell division – movements
c) Photosynthesis – respiration
d) Respiration – growth

24) Photophosphorylation was discovered by
1) Arnon 2) Calvin 3) Blackman 4) Warburg

25) As there is only 0.03% of carbondioxide in atmosphere and when the green plants on earth use carbondioxide every year, there is danger of scarcity of carbondioxide is
1) 100 years 2) About 100 years
3) After 3000 years 4) No danger at all

26) The first compound that accepts CO_2 during dark phase is
1) NADP 2) Ferridoxin 3) RUBP 4) Cytochrome

27) Percentage of water lost due to stomatal transpiration in a plant is
1) 40 –50% 2) 80-95% 3) 90-95% 4) 60-80%

28) Which of the following plants add more oxygen to atmosphere than it removes?
1) Rhizopus2) Aspergillus 3) Spirogyra 4) Puccinia

29) Cyclic photophosphorylation is confined to
1) Photosystem I 2) Photosystem II
3) Both the above 4) None of these

30) The mineral element present in the chlorophyll is
1) Iron 2) Magnesium 3) Sulphur 4) Calcium

31) Water molecule is destroyed during
1) Photosystem 2) Krebs cycle 3) Photolysis 4) Calvin cycle
32) Which of the following is a true element?
1) Fe 2) Zn 3) P 4) Mg
33) Synthesis of ATP during photosynthesis and respiration is an oxidation process which envolves energy from one of the following
1) CO_2 2) H_2O 3) O_2 4) Electrons
34) When turgor pressure is zero, then osmotic pressure is equal to
1) OP 2) DPD 3) DPD + OP 4) None
35) If the bark of the tree's is removed, then the plant will die due to
a) Leaves cannot carry photosynthesis
b) Water and salts absorbed by roots cannot reach shoot
c) Food material synthesised by leaves cannot be translocated to root
d) Shock
36) The pigment directly functioning in photosynthesis of batrachospermum?
1) R- phycoerythrin 2) Xanthophyll
3) R-phyeocyanin 4) Chlorophyll-a
37) A compound in calvin cycle which utilises ATP and NADPH in its formation is
1) GAP 2) PGA 3) RUBP 4) Erythrose
38) The function of ATP in the photosynthesis is the transfer of energy from
1) Dark reaction of light reaction 2) Light reaction to dark reaction
3) Chloroplast to mitochondria 4) Mitochondria to chloroplast
39) In C_4 plants, the primary acceptor of CO_2 is
1) RUBP 2) OAA 3) PEP 4) PGA
40) In Calvin cycle the CO_2 combines with
1) Diphosphoglyceric acid 2) Ribulose biphosphate
3) Phosphoglyceric acid 4) Fructose 1 –6, diphosphate
41) The discovery of Emerson enhancement effect provided the evidence for the existance of
a) Two separate pigment systems absorbing green and red lights but acting independently
b) Two separate pigment systems absorbing red and far red lights but acting simultaneously
c) Two separate reactions one taking place in grana and the other in stroma
d) None of the above
42) Plants with C_4 pathway of carbon fixation have anatomy in their leaves
1) Kranz anatomy 2) Normal type
3) Xerophytic type 4) Hydrophytic type
43) Reduction of 3 phosphologlyceric acid is completed with the synthesis of
1) OAA 2) PEP 3) GAP 4) None
44) ------ is the movement of plants influenced by the light
1) Geotropism 2) Hydrotropism
3) Thigmonasty 4) Phototropism
45) The process of photophosphorylation occurs within
1) Cristae 2) Matrix 3) Stroma 4) Grana
46) Two pigments systems in photosynthesis are discovered by
1) Van Niel 2) Arnoff 3) Embden 4) Emerson
47) Common activity of enzymes, Vitamins and hormones is
1) Regulation of metabolism 2) Regulation of reproduction

3) Regulation of respiration 4) None of the above

48) C_4 plants are also called
1) Hatch – Slack type 2) Calvin type
3) Blackmann type 4) None

49) In photosynthesis splitting of water and release of O_2 is during
1) Photolysis 2) Red drop
3) Photophosphorylation 4) Carboxylation phase

50) Hatch-Slack mechanism is reported in several plants by a researcher from Andhra Pradesh. His name is
1) M.S.Swaminathan 2) V.S.Ramdas
3) H.C.Arya 4) I.M.Rao

51) The first receiver of CO_2 in C_4 plants is
1) Oxaloacetic acid 2) Malic acid
3) Aspartic acid 4) Phosphoenol pyruvic acid

52) Water acts as electron donar in photo autotrophic plants was indicated by
1) Arnon 2) Van Niel 3) Rober Hill 4) Blackmann

53) In C_4 plants, the CO_2 fixation occurs in
1) Bundle sheath cells 2) Spongy mesophyll cells 3) Both 4) None

54) The first compound that accepts CO_2 during darkphase of photosynthesis is
1) PGA 2) OAA3) RUBP 4) PGAL

55) An organic substance bound to an enzyme and essential for the activity of the enzyme is called
1) Holo enzyme 2) Apoenzyme 3) Coenzyme 4) Isoenzyme

56) In maize, PEP carboxylation reaction takes place is
1) Bundle sheath cells 2) Mesophyll cells
3) Epidermis 4) Bundle sheath as well as mesophyllcells

57) The rate of photosynthesis is higher in
1) Red light 2) Green light 3) Continuous light 4) Very light intensity light

58) The term Zymase for enzymes in Yeast was coined by
1) Louis pasteur 2) Kuhne 3) Edward Buchner 4) Sumner

59) Reaction centre of PS I is
1) P_{660} 2) P_{680} 3) P_{690} 4) P_{700}

60) The intermediate that connects glycolysis and krebs cycle is
1) Oxalic acid 2) Pyruvic acid 3) Citric acid 4) Acetyl co.A

61) The enzyme code of enzyme 2.7.1.1 refers to the following main group
1) Avicennia 2) Vanda 3) Taeniophyllum 4) Loranthus

62) Munch massflow hypothesis mainly explains the long distance transport of
1) Mineral salts 2) Sugars 3) Proteins 4) Starch

63) In a plant physiology experiment a green plant kept in light was found releasing more units of $^{18}O_2$. Which of the following compounds would have been supplied to the plant?
1) $C_6H_{12}O_6$ containing $^{18}O_2$ 2) CO_2 containing ^{18}O
3) Ozone containing ^{18}O 4) H_2O containing ^{18}O

64) The terminal acceptor of electrons in non-cyclic photophosphorylation is
1) Plustoquinone 2) Plastocyanin 3) NADP 4) Ferridoxin

65) The scientist associated with the discovery of photosystems
1) Calvin 2) Hill 3) Emerson 4) Ruben

66) The 4-carbon compound formed during RuBp regeneration reactions of calvin cycle is
1) Sedoheptulose phosphate 2) Xylulose phosphate
3) Erythrose phosphate 4) Glyceraldehyde phosphate

67) Oxidative phosphorylation occurs in
1) Chloroplast 2) Mitochondria3) Peroxisome 4) Ribosome

68) The terminal acceptor of electrons in non-cyclic photophosphorylation is
1) Plastoquinone 2) Plastocyanin 3) NAD phosphate 4) Ferridoxin

69) The scientist associated with the discovery of photosystems
1) Calvin 2) Hill 3) Emerson 4) Ruben

70) The 4-carbon compound formed during RuBp regeneration reactions of calvin cycle is
1) Sedoheptulose phosphate 2) Xylulose phosphate
3) Erythrose phosphate 4) Glyceraldehyde phosphate

71) Chlorophyll containing roots are found in
1) Avicennia 2) Vanda 3) Taeniophyllum 4) Loranthus

72) The peroxisomal enzyme which catalyses the conversion of glycolate to glyoxylate belongs to this category
1) Oxidoreductase 2) Hydrolases 3) Lyases 4) Isomerases

73) Which of the component of photosynthetic electron transport is directly involved in the transport of protons form stroma to lumen of thylakoid?
1) Plastocyanin 2) Plastoquinone 3) Ferredoxin 4) Pheophytin

74) Which one of the following is not associated with ascent of sap in tall trees?
a) Cohesion and adhesion of water molecules
b) Continuity of water column
c) Pressure in tracheary elements
d) Transpiration pull

75) The risk of spoilage is less in salted pickles because of
1) Guttation 2) Plasmolysis 3) Imbibition 4) Diffusion

76) Which of the following is needed in photosynthesis and respiration
1) Chlorophyll 2) CO_2 3) O_2 4) Cytochromes

Keys

1)3	2)4	3)4	4)1	5)4	6)2	7)4	8)4	9)3
10)4	11)3	12)1	13)1	14)1	15)3	16)3	17)3	18)3
19)1	20)2	21)2	22)2	23)3	24)1	25)4	26)3	27)2
28)3	29)1	30)2	31)3	32)2	33)4	34)2	35)3	36)4
37)1	38)2	39)3	40)2	41)2	42)1	43)3	44)4	45)4
46)4	47)1	48)1	49)1	50)2	51)4	52)2	53)3	54)3
55)3	56)2	57)1	58)3	59)4	60)4	61)3	62)2	63)4
64)3	65)3	66)3	67)2	68)3	69)3	70)3	71)3	72)1
73)2	74)3	75)2	76)4					

Ex-2

1) The correct equation of photosynthesis is

1) $6CO_2+6H_2O \xrightarrow[\text{Chlorophytes}]{\text{Light}} C_6H_{12}O_6+6O_2+6H_2O$

2) $6CO_2+6O_2 \xrightarrow[\text{Chlorophytes}]{\text{Light}} C_6H_{12}O_6+6O_2+6H_2O$

3) $6CO_2+12H_2O \xrightarrow[\text{Chlorophytes}]{\text{Light}} C_6H_{12}O_6+6O_2+6H_2O$

4) $6CO_2+12H_2O \xrightarrow[\text{Chlorophytes}]{\text{Light}} C_6H_{12}O_6+6O_2$

2) The place which acts as proton reservior in chloroplast is
1) Granum 2) Stromathylakoids
3) Lumen of the thylakoids 4) Stroma
3) Chlorophyll –a is absent in
1) Cyanobacteria 2) Photosynthetic bacteria
3) Red algae 4) Brown algae
4) In the chlorophyll molecular structure, a twenty carbon part is attached to
1) Phytor tails 2) 4^{th}, ring of porphyrin
3) 3^{rd}, ring of porphyrin 4) 1^{st} ring of porphyrin
5) Chlorophyll-b is found
1) In higher plants and chlorophyceae
2) In higher plants and phaeophyceae
3) In higher plants and Rhodophyceae
4) In all types of algae
6) Chlorophyll-c is seen in
1) Chlorophyceae & Bacillariophy ceae
2) Cyanophyceae & Rhodophyceae
3) Rhodophyceae & Phaeophyceae
4) Bacillariophyceae & Phaeophyceae
7) The molecular formula of chlorophyll-a is
1) $C_{55}H_{72}O_5N_4Mg$ 2) $C_{55}H_{70}O_6N_4Mg$
3) $C_{55}H_{72}O_4N_4Mg$ 4) $C_{50}H_{72}O_5N_4Mg$
8) The molecular formula of chlorophyll-b is
1) $C_{55}H_{72}O_5N_4Mg$ 2) $C_{55}H_{70}O_6N_4Mg$
3) $C_{55}H_{72}O_4N_4Mg$ 4) $C_{50}H_{72}O_4N_4Mg$
9) Oxygenate hydrocarbons are
1) Carotenes 2) Xanthophylls 3) Phycocyanins 4) Phycoerythrins
10) In chlorophyll 'a' the methyl group is attached to the
1) 1^{st} carbon atom 2) 2^{nd} carbon atom
3) 3^{rd} carbon atom 4) 4^{th} carbon atom
11) One of the following molecular structure has four straightened pyrrol rings without magnesium
1) Carotenes 2) Xanthophylls 3) Phycobilins 4) Chlorophylls
12) Photosynthetically active radiation (PAR) ranges from
1) 350nm – 650nm 2) 390nm –700nm
3) 400nm – 850nm 4) 200nm –600nm
13) Action spectrum is the graph showing
1) Rate of photosynthesis at different light wave lengths
2) Rate of a specific absorption of light at different wave lengths
3) Rate of carbon assimilation in darkphase
4) Rate of synthesis of ATP and $NADPH_2$
14) Assimilatory power is in the form of
1) ATP, $NADPH_2$ and $FADH_2$ 2) ATP, GTP and $NADH_2$
3) ATP, $NADPH_2$ 4) ATP, $NADH_2$ and $NADPH_2$
15) Photophosphorylation means
1) Synthesis of ATP by using oxidation energy
2) Synthesis of ATP by using energy from H_2O reduction

3) Synthesis of ATP by using light energy
4) Synthesis of ATP by using mechanical energy

16) Radio active elements used in photosynthesis
1) $O^{18}C^{14}P^{32}$ 2) $O^{18}C^{12}$ 3) $O^{18}C^{16}P^{32}$ 4) $O^{18}C^{14}$
17) Potassium ferric oxalate is an acceptor of
1) O 2) H 3) C 4) N
18) Ruben & Kamen by using H_2O^{18} in their experiment reported that, the source of O_2 evolved during photosynthesis is from
1) $NADH_2$ 2) $NADPH_2$ 3) H_{25} 4) H_2O
19) The hydrogen donor in bacterial photosynthesis is
1) H_2O 2) H_2S 3) HCl 4) H_2SO_4
20) The transfer of the radiant energy trapped by all photosynthetic pigments in the antenna to the reaction center is called
1) Stratification 2) Inductive resonance 3) Activation 4) Excitation
21) Robert Emerson conducted Experiment in
1) Chlorella 2) Scenedesmus 3) Spinach chloroplasts 4) Pandorina
22) Chlorophyll-a and chlorophyll-b in the LHC –1 are present in the ratio of
1) 3:2 2) 3:1 3) 3:3 4) 4:3
23) P_{700} is a
1) Special type chlorophyll-a 2) Normal chlorophyll-a
3) Special type chlorophyll-b 4) Normal type chlorophyll-b
24) Total number of chlorophyll-a and b present in LCH –II is
1) 200 2) 300 3) 100 4) 250
25) Numerous xanthophylls are associated to
1) PS I only 2) PS II only 3) Both PS I & PS II 4) None of the above
26) Decrease of photosynthesis beyond 680nm of the vesible spectrum is called
1) Blink effect 2) Red drop 3) Gibb's effect 4) Warburg effect
27) OEC (Oxygen evolving complex) is responsible for
1) Photophosphorylation 2) Photolysis of water
3) Resonance transfer 4) CO_2 reduction
28) OEC is located in the
1) Granathylakoid surface 2) Stromathylakoid surface
3) Stroma 4) Lumen side of thylokoid
29) Non cyclic electron transport requires the participation of
1) PS I 2) PS II 3) PS I and PS II 4) None of the above
30) Light cyclic electron transport requires the participation of
1) ATP synthase 2) Fd-NADP Oxidoreductase
3) PQ 4) Cytb – f complex
31) The total number of protons required to get transported through CFo –CF1 complex to produce one ATP is
1) 6 2) 2 3) 12 4) 3
32) PQ accepts H^+ protons from
1) Lumen of thylakoids 2) Stroma
3) H_2O 4) $NADPH_2$
33) Electrons from P_{680} are received by
1) Plastoquinol 2) Phenophytin 3) Plastocyanin 4) Ferridoxin
34) In the structure of pheophytin, Mg^{2+} ion is replaced by
1) two NH_2 2) two Mn^{2+} 3) tow (H) 4) two Fe^{2+}
35) The electrons from PQH_2 are transferred to

1) Quinone 2) Plastocyanin
3) Cytochrome –f 4) Cytochrome b_6 – f complex

36) Ferridoxin is
1) Iron – protein 2) Iron – phosphorous protein
3) Iron – Molybdenum 4) Iron – sulphur protein

37) Non cyclic electron transport, $2e^-$ yields
1) One $NADPH_2$ and two ATP 2) Two $NADPH_2$ and four ATP
3) Two $NADPH_2$ and three ATP 4) One $NADPH_2$ and one ATP

38) The first stable compound of PCR is
1) 3 – Phosphoglyceriacid 2) Glyceraldehyde 3 – phosphate
3) Dihydroxy acetone phosphate 4) Glucose

39) The carboxylation in PCR cycle is catalysed by
1) PEP – Carboxylase 2) RUBISCO
3) Pyruvic – carboxylase 4) Triose phosphate – decarboxylase

40) One of the following is an abundant protein in plant kingdom
1) PEP carboxylase 2) Aldolase
3) Alcoholdehydrogenase 4) RUBISCO

41) The enzyme catalysing the synthesis of Fructose 1, 6- bisphosphate is
1) Fructose 1, 6 – bisphosphatase 2) Tranketolase
3) Aldolase 4) Phosphoglycerokinase

42) Transaldolase catalyses the synthesis of
1) Fructose 1, 6 –bisphosphate 2) Sedoheptulose 1, 7 – bisphosphate
3) Erythrose 4 – phosphate 4) Ribose 5 – Phosphate

43) The synthesis of xylulose 5 (p), Erythrose 4 (p) and Ribose 5 (p) catalysed by
1) Transaldolase 2) Transketolase
3) Aldolase 4) Phosphoglycerokinase

44) For the synthesis of the hexose sugar, the required assimilatory power is
1) $3ATP + 2NADPH_2$ 2) $18ATP + 12NADPH_2$
3) $18ATP + 12NADH_2$ 4) $6ATP + 6NADPH_2$

45) Sugar cane is a
1) C_4 – Plant 2) C_3 – Plant 3) CAM – Plant 4) None of the above

46) C_4 path way is exhibited by plants belonging to
1) 19 families 2) 15 families
3) 4 families 4) 20 families

47) Agranal type of chloroplasts are
1) Mesophyll chloroplast 2) Bundle sheath chloroplasts
3) Epidermal chloroplast 4) Cupshaped chloroplast

48) Kranz anatomy is a morphological diversity in the leaves of
1) C_3 – plants 2) C_3 plants of hill region
3) C_4 plants 4) CAM plants

49) In C_4 pathway, Calvin cycle occurs in
1) Mesophyll chloroplast 2) Bundle sheath chloroplast
3) Mesophyll cell 4) None of the above

50) PEP carboxylase is present in
1) Bundle sheath chloroplast 2) Mesophyll chloroplast
3) Mesophyll cell 4) None of the above

51) First carboxylation in C_4 plants leads to the synthesis of
1) Malic acid 2) Asparatate
3) Phosphoenol pyruvate 4) Oxaloacetate

52) Number of ATP required for the synthesis of one glucose molecule by C_4 plants is
1) 18 2) 30 3) 12 4) 6

53) Plants living in shades are called as
1) Heliphytes 2) Eremophytes 3) Psilophytes 4) Sciophytes

54) Cyclic electron transport in Rhodosphirillum rubrum was first demonstrated by
1) Arnon 2) Emerson 3) Frankel 4) Kamen

55) Chemiosmotic theory was proposed by
1) Peter Mitchell 2) Arnon 3) Emerson 4) Blink

56) Match the following:

Pigment	Character	Occurence
I) Pyycobilins	Water soluble accessory pigment	Cyano bacteria
II) Carotenes	Water soluble accessory pigment	Red algae
III) Chl-C	Water insoluble main pigment	Brown algae
IV) Zeaxainthin	Water soluble main pigment	Blue green algae

Which two show the correct combination?
1) I & III 2) II & IV 3) I & IV 4) IV & V

57) Match the following:

Substrate	Enzyme	Type of reaction
I) 1 –3 bis PGA	GAP dehydrogenase	Reduction
II) RUBP	RUBISCO	Condensation
III) Xylulose 5 – phosphate	Ribulose –5 – epimerase	Epimerisation
IV) Fructose 1 –6 – bis phosphate	Fructose 1 –6 bis phosphatase	Isomerisation

Which two shows the correct combination?
1) I & III 2) II & III 3) I & II 4) III & IV

58) Match the following:

Substrate	Enzyme	Product
I) RUBP	RUBISCO	C_4 acid
II) Pyruvic acid	Pyruvate kinase	C_3 acid
III) Phosphoenool pyruvate	PEP kinase	C_3 acid
IV) Oxalo acetate	malate dehydrogenase	C_3 acid

Which two shows the correct combination?
1) I & III 2) II & IV 3) II & III 4) III & IV

59) Study the following table:

List –I	List –II
A) Assimilatory power	I) Blue light
B) Photosynthetic rate	II) Electro Magnetic Energy
C) Photon	III) Phycobillin
D) Carotenoids	IV) ATP and NADPH + H^+
	V) Action spectrum

1) A-IV, B-III, C-II, D-I 2) A-II, B-III, C-V, D-I
3) A-III, B-IV, C-V, D-II 4) A-IV, B-V, C-II, D-I

60) Study the following table:

List –I	List –II
A) Hatch & slack	I) C_3 acid
B) PGA	II) Kranz anatomy
C) C_4 plant	III) Bundle sheath cells
D) PCR cycle	IV) OAA
	V) Dicarboxylic acid pathway

1) A-I, B-II, C-V, D-IV 2) A-V, B-I, C-II, D-III
3) A-III, B-I, C-V, D-IV 4) A-II, B-III, C-IV, D-I

61) Assertion: Photolysis of H2O and evolution of O_2 occur in the lumen of thlykoids
Reason: OEC is located on the lumen side of thylakoid membrane
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

62) Assertion: The formation of hexose sugar through PCR cycle requires 12NADPH+H^+ and 18ATP
Reason: The assimilation of 6 molecules of CO_2 results in the formation of one hexose sugar in photosynthesis
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

63) Assertion: Pyruvic acid is transported from B.S cells to mesophyll cells in C_4 plants
Reason: Decarboxylation of Malic acid occurs in mesophyll cells of C_4 plants
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

64) Assertion: Cyclic photophosphorylation is an inefficient way of harvesting light
Reason: Cycle photophosphorylation uses light energy to build ATP from ADP & inorganic phosphate
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

Keys

1)3	2)3	3)2	4)2	5)1	6)4	7)1	8)2
9)2	10)3	11)3	12)2	13)1	14)3	15)3	16)4
17)2	18)4	19)2	20)2	21)1	22)2	23)1	24)4
25)2	26)2	27)2	28)4	29)3	30)1	31)4	32)2
33)2	34)3	35)4	36)4	37)1	38)1	39)2	40)4
41)3	42)2	43)2	44)2	45)1	46)1	47)2	48)3
49)2	50)2	51)4	52)2	53)4	54)3	55)1	56)1
57)1	58)2	59)4	60)2	61)1	62)1	63)3	64)4

Respiration

Ex-1

1) Respiration rate in an organism
1) Increases by rise in temperature 2) Decrease by rise in temperature
3) Remains unaffected by temperature
4) Records a shape fall with every 100^0C rise in temperature

2) CO_2 in the atmosphere remains relatively constant because

1) CO_2 is converted to carbohydrate during photosynthesis
2) CO_2 is converted to $CaCO_3$
3) Bacteria use up CO_2
4) CO_2 is released in respiration & photosynthesis takes place during day time

3) Glycolysis ends with
1) Pyruvic acid 2) Lactic acid 3) Succinic acid 4) Malic acid

4) Cellular respiration in the absence of molecular oxygen is
1) Photorespiration 2) Glycolysis 3) Krebs cycle 4) Citric acid cycle

5) The energy released during respiration is
1) Lost at heat 2) Stored in ATP
3) Utilized in photosynthesis 4) Stored in ADP

6) What enzyme in respiration is connected with the release of electrons?
1) Oxidase 2) Carboxylase 3) Dehydrogenase 4) Fumarase

7) In plants during respiration
1) O_2 is utilised and CO_2 is released 2) CO_2 is utilised
3) Both 4) None

8) In plants cells energy is stored in the form of
1) Citric acid 2) Glucose 3) ATP 4) AMP

9) RQ value is one in case of
1) Fatty acids 2) Nucleric acid 3) Carbohydrates 4) Organic acids

10) Which of the following statements is correct
1) Plants carry on photosynthesis during the day and respiration all the time
2) Plants carry on photosynthesis during night and respiration during the day
3) Plants carry on photosynthesis all the time
4) None

11) If respiration takes place at a greater speed than photosynthesis, the plant will
1) Become thin and tall 2) Finally die of starvation
3) Show no change 4) Grow healthy due to more energy

12) The intermediate compound common for Aerobic and Anaerobic respiration is
1) PGA 2) Acetic acid 3) Pyruvic acid 4) Succinic acid

13) Which two life functions given in a group below are not alike?
1) Photosynthesis – Protein synthesis 2) Cell division – Movements
3) Photosynthesis – Respiration 4) Respiration – Growth

14) If the RQ is 0.7 for a plant, the respiratory substrate is
1) Carbohydrate 2) Proteins 3) Sugars 4) Fats & Oils

15) The enzyme that converts glucose into ethyl alcohol & CO_2 is
1) Zymase 2) Invertase 3) Diastase 4) Maltase

16) Synthesis of ATP during photosynthesis & respiration is an oxidation process which evolves energy form one of the following
1) CO_2 2) H_2O 3) O_2 4) Electrons

17) Without the conversion of pyruvate to lactate or ethanol, glycolysis will close because of exhaustation of
1) ADP 2) CoA 3) H_2O 4) NAD

18) The initiation of Citric acid cycle is with
1) Succinic acid 2) Oxaloacetic acid 3) Acetyl CoA 4) Citric acid

19) Glycolytic pathway & Krebs cycle are connected by
1) Pyruvic dehydrogenase 2) Succinyl dehyrogenase
3) Acetyl co enzyme –A 4) None of the above

20) RQ is unity when the respiratory substrate is

1) Fat 2) Protein 3) Organic acid 4) Carbohydrate

21) When glucose is anaerobically broken, the number of ATP producing is
1) 2 2) 38 3) 40 4) 36

22) Krebs cycle takes place in
1) Cytoplasm 2) Stroma of the chloroplast
3) Peroxisomes 4) Mitochondria matrix

23) The number of ATP released when glucose is converted to ethyl alcohol & CO_2 is
1) 20 2) 40 3) 10 4) 2

24) The enzymes involved in glycolysis are
1) Hexokinase & dehydrogenase 2) Hexokinase & enolase
3) Enolase & Alcohol dehydrogenase 4) Enolase & Succinic dehydrogenase

25) NADH $+H^+$ are formed during the following reactions converting
1) Glucose – 6 – phosphate to fructose –6 – phosphate
2) 3 –phosphoglyceraldehyde to phosphoglyceric acid
3) Phosphoglycerate to pyruvate
4) Fructose 1 –6 – bisphosphate to two triose isomers

26) In TCA cycle, FAD is reduced in the conversion of
1) Malate to OAA 2) Fumarate to malate
3) Succinic acid to fumaric acid 4) Succinic CoA to succinate

27) The energy rich intermediate compound in breakdown of carbohydrate, fatty acids & amino acids is
1) Acetyl CoA 2) Succinyl CoA 3) Pyruvate 4) ATP

28) Good example of substrate level phosphorylation in EMP pathway is chemical conversion is
1) Glucose $\rightarrow$ G.6.P 2) 3 PGAL $\rightarrow$ DHAP
3) 1, 3 DPGA $\rightarrow$ 3 PGA 4) 3 PGA $\rightarrow$ 2PGA

29) In anaerobic respiration, number of ATP per glucose is
1) 38 2) 36 3) 2 4) 6

30) Breakdown of carbohydrate during respiration is called
1) Calvin cycle 2) Glycolysis 3) Nitrogen cycle 4) Hatch-Slack cycle

31) If O_2 is absent, the end product of respiration is
1) $CO_2 + H_2O$ 2) Ethyl alcohol + CO_2 3) O_2 4) Carbohydrate

32) Krebs cycle is also called
1) TCA cycle 2) Citric acid cycle
3) Tricarboxylic acid cycle 4) All given in 1, 2, 3

33) Fructose 1 –6 bisphosphate splits into two triose phosphates by the enzyme
1) Hexoseisomerase 2) Hexokinase 3) Aldolase 4) Dehydrogenase

34) One gram molecule of glucose through aerobic respiration produces the following ATP molecules
1) 40 2) 38 3) 36 4) 34

35) The site of EMP pathway in the cell is
1) Inner membrane of mitochondria 2) Matrix of mitochondrion
3) Cytoplasm 4) Peroxisome

36) Respiratory quotient during early stages of germination of castor seed is
1) 1 2) More than one 3) Zero 4) Less than one

37) The intermediate that connects glycolysis and Krebs cycle is
1) Oxalic acid 2) Pyruvic acid 3) Citric acid 4) Acetyl CoA

38) The number of oxidations involving NAD in Krebs cycle is
1) 4 2) 3 3) 2 4) 5

39) When fats are the respiratory substrate RQ is
1) Zero 2) One 3) Less than one 4) More than one
40) Oxidative phosphorylation occurs in
1) Chloroplast 2) Mitochondrion 3) Peroxisome 4) Ribosome
41) How many ATP molecules are formed in electron transport form the reduced Nicotinamide Adenine dinucleotides generated in one turn of Krebs cycle
1) 3 2) 2 3) 9 4) 12
42) Which of the following is needed both in photosynthesis and respiration?
1) Chlorophyll 2) CO_2 3) O_2 4) Cytochromes

Keys

1)1	2)4	3)1	4)2	5)2	6)1	7)1
8)3	9)3	10)1	11)2	12)3	13)3	14)4
15)1	16)4	17)4	18)3	19)3	20)4	21)2
22)4	23)4	24)2	25)2	26)3	27)1	28)3
29)3	30)2	31)2	32)4	33)3	34)3	35)3
36)4	37)4	38)2	39)3	40)2	41)3	42)4

Ex-2

1) In green plants respiration occurs only
1) When stomata are open 2) When photosynthesis ceases
3) When photosynthesis is in progress 4) Always
2) Main substrate of respiration in plants is
1) Lipids 2) Fats 3) Organic acids 4) Carbohydrates
3) Which one is 'energy currency' of cell?
1) ATP 2) NADH 3) $FADH_2$ 4) $NADPH_2$
4) The amount of energy released from ATP by hydrolysis is
1) 7.6k cal 2) 76 k cal 3) 760 k cal 4) 7600 k cal
5) The six oxidation reactions of aerobic respiration are inter linked with
1) Addition of H_2 atoms 2) Release of H_2 atoms
3) Hydrogenation reactions 4) Dehydration reactions
6) The two types of respirations (aerobic and anaerobic) can be recognised on the basis of
1) Release of energy 2) CO_2 utilization
3) Involvement of O_2 4) Release of ATP
7) Complete oxidation of one glucose molecule results in the release of
1) 18 k cal 2) 118 k cal 3) 618 k cal 4) 686 k cal
8) Partial oxidation of one glucose molecule occurs in
1) Cytoplasm 2) Mitochondria3) Cristae 4) Matrix
9) The common pathway between aerobic and anaerobic respiration is
1) Glycolysis 2) Kreb's cycle
3) ETS cycle 4) Oxidative phosphorylation
10) The amount of energy still hidden in the end products of anaerobic respiration is
1) 6,86,000 cal 2) 56,000 cal 3) 6,30,000 cal 4) 2 ATP
11) Number of dehydrogenation reactions occuring in aerobic respiration is
1) 6 2) 4 3) 2 4) 8
12) The site of Glycolysis is

1) Mitochondrial matrix 2) Oxysomes 3) Cytoplasm 4) Oxydates

13) The metallic activator required for most of the reactions of glycolysis is
1) Fe 2) Mg 3) Mn 4) Cu

14) Enzyme responsible for cleavage reactions in glycolysis is
1) Kinase 2) Aldolase 3) Enolase 4) Isomerase

15) Number of phosphorylation reactions involved in glycolysis is
1) 4 2) 3 3) 6 4) 2

16) During the conservation of GAP to 1, 3 Bis PGA, the required phosphate comes from
1) ATP 2) $NADPH_2$ 3) $H_2PO_4^-$ 4) ADP

17) The byeproduct formed during biological oxidation in glycolysis is
1) 3PGA 2) 1, 3 Bis PGA 3) PEP 4) GAP

18) Conversion of 3 –PGA to 2 –PGA in glycolysis is an example for
1) Phosphorylation 2) Intramolecular shift
3) Dehydration 4) Cleavage

19) In glycolysis dehydration reaction in catalysed for
1) Mutase 2) Enolase 3) Pyruvic kinase 4) Hexokinase

20) Number of ATP formed by substrate level phosphorylation in glycolysis are
1) 4 2) 2 3) 6 4) 38

21) Glycolysis can be represented by the formula
1) $C_6H_{12}O_6 \rightarrow 2C_3H_4O_3+4H$ 2) $C_6H_{12}O_6 \rightarrow 2C_2H_5OH+2CO_2$
3) $C_6H_{12}O_6+6O_2 \rightarrow 6CO_2+6H_2O$ 4) $6CO_2+6H_2O \rightarrow C_6H_{12}O_6+6O_2$

22) Pyruvic acid enters into Kreb's cycle via
1) Phosphoenol pyruvate 2) 2 –PGA
3) 3 –PGA 4) Acetyl CoA

23) Which of the following is not required during glycolysis
1) Mg 2) Cytosol 3) Glucose 4) Oxygen

24) For every molecule of glucose during glycolysis, the ratio between pyruvic acid liberated and net gain at of ATP molecules formed is
1) 1:1 2) 2:1 3) 2:3 4) 3:1

25) The connecting link reaction between glycolysis and Kreb's cycle occurs in
1) Cytosol 2) Cristae 3) Peroxisomes 4) Mitochondrial matrix

26) The connecting reaction between glycolysis and Kreb's cycle is an example for
1) Oxidative phosphorylation 2) Oxidative decarboxylation
3) Ligation 4) Dehydrogenation

27) In the absence of oxygen, pyruvic acid enters into
1) Anaerobic respiration 2) Kreb's cycle
3) Mitochondrial matrix 4) Mitochondrial cristae

28) The site of oxidative decarboxylation of pyruvic acid is
1) Cytosol 2) Perimitochondrial space
3) Perimitochondrial matrix 4) Cristae

29) The alternate name for Kreb's cycle is
1) C2 – cycle 2) Dicarboxylic acid cycle
3) Tricarboxylic acid cycle 4) EMP pathway

30) The enzyme involved in both dehydration and hydration reactions of Kreb's cycle is
1) Dehydrogenase 2) Decarboxylase 3) Kinase 4) Aconitase

31) Product of first biological oxidation in Kreb's cycle is
1) Isocitric acid 2) Oxalosuccinic acid
3) α-Ketoglutraric acid 4) Succinic acid

32) Conversion of GTP to ATP during respiration is an example for

1) Oxidative decarboxylation 2) Transamination
3) Isomerisation 4) Transphorylation

33) Enzyme catalysing the cleavage reaction in Kreb's cycle is
1) Succinic thiokinase 2) Succinic dehydrogenase 3) Fumerase 4) Aconitase

34) The 5-carbon organic acid of the Kreb's cycle-a key compound in the nitrogen metabolism of the cell is
1) Fumaric acid 2) Oxalosuccinic acid 3) Citric acid 4) α -Ketoglutaric acid

35) The term fermentation was coined by
1) L Pasteur 2) Beijerinck 3) Gay Lussac 4) Lipman

36) During Kreb's cycle GTP is formed between
1) Oxlosuccinate to α Keto glutarate 2) α Keto glutrate to succinly CoA
3) Succinyl CoA to Succinate 4) Succinate to Fumarate

37) Complete oxidation of pyruvic acid results in the formation of these end products
1) CO_2 & H_2O 2) CO_2 & malic acid 3) CO_2 & ethyl alcohol 4) CO_2 & OAA

38) Number of iron sulphur proteins present in complex II (Succinic dehydrogenase) is
1) 6 2) 3 3) 2 4) 1

39) One turn of Kreb's cycle yields
1) $3NADH_2$, $1FADH_2$, 1GTP 2) $2NADH_2$, $2FADH_2$, 1GTP
3) $4NADH_2$, $1FADH_2$, 1GTP 4) $3NADH_2$, $2FADH_2$, 1GTP

40) The total number of ATP produced from cytosol $NADH+H^+$ is
1) 6 2) 4 3) 8 4) 2

41) During ATP synthesis, electrons pass through
1) Cytochromes 2) Water 3) O_2 4) CO_2

42) Net gain of ATP when pyruvate is respired aerobically
1) 12 ATP 2) 15 ATP 3) 20 ATP 4) 17 ATP

43) Fementation was discovered by
1) L Pasteur2) Lipman 3) Sir Hans Krebs 4) Gay Lussac

44) Synthesis of ATP in mitochondria requires
1) NADP 2) FMN3) Oxygen 4) Pyruvic acid

45) Number of Copper containing proteins present in the complex IV is
1) 2 2) 3 3) 6 4) 4

46) Number of ATP liberated by the oxidation of one cytosol $NADH_2$ and one $FADH_2$ is
1) Two 2) Three 3) Four 4) Five

47) The net gain of ATP in aerobic respiration is
1) 38 2) 40 3) 36 4) 34

48) Enzymes involved in the incomplete oxidation of pyruvic acid during anaerobic respiration are
1) Isomeric and Kinase 2) Decarboxylase and Dehydrogenase
3) Decarboxylase and Kimase 4) Isomerase and Dehydrogenase

49) The net gain of ATP during anaerobic respiration is
1) 0 2) 2 3) 38 4) 48

50) One of the following undergoes reduction during alcoholic fermentation
1) Pyruvate 2) Acetaldehyde 3) Acetyl CoA 4) PEP

51) Respiratory quotient is represented by
1) C/N 2) N/C 3) CO_2/O_2 4) O_2/CO_2

52) The value of R.Q if glucose is the respiratory substrate is
1) One 2) Two 3) Zero 4) Infinity

53) Value of RQ in anaerobic respiratory in which carbohydrate is used as a respiratory substrate is

1) One 2) 1.33 3) 0.7 4) Infinity

54) If respiratory substrate is rich in oxygen, the value of RQ is
1) One 2) <1 3) >1 4) Can't be estimated

55) RQ value will be less than one is
1) Saccharum and Oryza 2) Archis and Ricinus
3) Beta and Ipoemea 4) Manihot and Beta

56) Study the following List:

List –I	List –II
A) Cleavage B) Intra molecular shift C) Dehydration D) Second dephosphorylation	I) Enolase II) Pyruvic kinase III) Mutase IV) Aldolase decarboxylation

1) A-III, B-IV, C-I, D-II 2) A-IV, B-III, C-I, D-II
3) A-IV, B-I, C-III, D-II 4) A-III, B-I, C-IV, D-II

57) Study the following List:

List –I	List –II
A) Complex IV B) Complex I C) Complex III D) Complex V	I) Cytochrome C reductase II) ATP synthase III) NADH dehydrogenase IV) Cytochrome C Oxidase

1) A-IV, B-III, C-I, D-II 2) A-IV, B-III, C-II, D-I
3) A-IV, B-I, C-III, D-II 4) A-II, B-IV, C-I, D-III

58) Observe the following data:

Substrate	Product	Co enzyme
I) Cis-aconitic acid II) Malic acid III) Iso citric acid Oxalo succinic acid IV) Succinic acid	Isocitric acid Fumaric acid Fumaric acid	$FADH_2$ $NADH+H^+$ $NADH+H^+$ $FADH_2$

Which two show the correct combination?
1) I and II 2) II and IV 3) II and III 4) IV and I

59) In aerobic respiration decarboxylation takes place at
I) Glycolysis II) Kreb's cycle III) In between glycolysis and Krebs cycle
The correct combination is
1) II alone is correct 2) II and III are correct
3) I and II are correct 4) I and III are correct

Keys

1)4	2)4	3)1	4)1	5)2	6)3	7)4
8)1	9)1	10)3	11)1	12)3	13)2	14)2
15)4	16)3	17)2	18)2	19)2	20)1	21)1
22)4	23)4	24)1	25)4	26)2	27)1	28)3
29)3	30)4	31)2	32)4	33)2	34)4	35)1
36)3	37)1	38)3	39)1	40)2	41)1	42)2
43)4	44)3	45)1	46)3	47)3	48)2	49)2
50)2	51)3	52)1	53)4	54)3	55)2	56)2
57)2	58)1	59)3				

Nitrogen Metabolism

Ex –1

1) Plants used for increasing the fertility of soil
   1) Napier grass, Acacia sp 2) Azolla, Sesbania, Medicago
   3) Paddy, Wheat, Maize 4) Jute, cotton
2) Microorganisms which can fix nitrogen in both free living condition and symbiotic condition are
   1) Azatobacter, Rhizobium 2) Clostridium, Rhodospirillum
   3) Nostoc, Anabaena 4) Klebsiella, Actinomycetes
3) Aerobic nitrogen fixing bacterium is
   1) Azotobacter 2) Clostridium 3) Rhodospirillum 4) Rhodomicrobium
4) Anaerobic, non-photosynthetic, nitrogen fixing bacterium is
   1) Azotobacter 2) Clostridium 3) Rhodospirillum 4) Anabaena
5) Anaerobic, photosynthetic, nitrogen fixing bacterium is
   1) Azotobacter 2) Clostridium 3) Rhodospirillum 4) Anabaena
6) The N_2 fixing bacterium present in the leaf nodules of Psychotria is
   1) Rhizobium 2) Clostridium 3) Rhodosprillium 4) Klebsiella
7) The microbe present in the root nodules of Alnus & Casuraina is
   1) Actinomycetes 2) Rhizobium 3) Klebsiella 4) Azatobacter
8) Organism that lives as a symbiotic nitrogen fixing system in the leaves of aquatic pteridophyte, Azolla is
   1) Nostoc 2) Rhizobium 3) Anabaena 4) Actinomycetes
9) Correct sequence in the nitrogen metabolism of nitrogen fixing micro-organisms is
   1) Protein synthesis $\rightarrow$ Amino acid synthesis$\rightarrow$ Nitrogen fixation
   2) Amino acid synthesis$\rightarrow$ Protein synthesis $\rightarrow$ Nitrogen fixation
   3) Nitrogen fixation$\rightarrow$ Protein synthesis$\rightarrow$ Amino acid synthesis
   4) Nitrogen fixation$\rightarrow$ Amino acid synthesis$\rightarrow$ protein synthesis
10) Higher plants take up nitrogen from the soil mostly in the form of
    1) N_2 2) NO_3^- 3) NH_4^+ 4) NO_2^-
11) Atmospheric nitrogen is fixed in the soil mostly in the form of
    1) Nitrate 2) Ammonia 3) Nitrite 4) Hydroxyl amine
12) Root of legume plant produces the following substance to attract the Rhizobium bacteria
    1) Carbohydrates 2) Amino acids
    3) Proteins 4) Sugars & amino acids
13) The bacterium, Rhizobium enters into the roots of the leguminous plant through
    1) Root hairs 2) Cortical cells 3) Pericycle 4) Stele
14) Nitrogenase enzyme is produced by
    1) Legume root nudules 2) Rhizobium bacterioids
    3) Rhizobium bacterium 4) Leghaemoglobin pigment
15) Curling of root hairs of the leguminous plant is caused by
    1) Multiplication of the Rhizobium bacteria
    2) Secretion of amino acid & sugars
    3) Production of hormones by the roots
    4) Data insufficient
16) Cell wall degrading enzyme produced by the bacterium Rhizobium are
    1) Nitrogenase and cellulase 2) Cellulase & pectinase
    3) Nitrogenase & pectinase 4) Hemicellulase
17) Reduction of dinitrogen to ammonia is catalysed by the enzyme
    1) Nitrogenase 2) Nitrate reductase 3) Nitrite reductase 4) Kinase

18) Corolloid roots of Cycas help the plants in
1) Absorption of water 2) Absorption and fixation of N_2
3) Anchorage 4) Additional support
19) In the reduction of dinitrogen to ammonia, the number of ATP utilized is
1) 12 2) 15 3) 16 4) 18
20) The sequence of amino acids present in the protein is determined by
1) t –RNA 2) r – RNA 3) Ribosome 4) Nucleotide sequence of DNA
21) The building blocks of proteins are
1) Amino acids 2) Nucleotides 3) Nucleosides 4) Ribosomes
22) Which pigment is essential for nitrogen fixation by legume plants
1) Anthocyanin 2) Phycocyanin
3) Leghaemoglobin 4) Phycoerythrin
23) Bulk of Nitrogen in nature is fixed by
1) Lightening 2) Denitrifying bacteria
3) Symbiotic bacteria 4) Chemical industries
24) Plants obtain their nitrogen supply through the bacteria of soil because
1) Nitrogen is found only in the soil
2) They cannot use atmospheric nitrogen directly
3) Bacteria are abundant in the soil
4) Plants can not grow without contact with soil
25) Element molybdenum is associated with
1) Nitrogen metabolism 2) Fat metabolism
3) Carbohydrate metabolism4) Translocation of sugars
26) An enzyme system called Nitrogenase is present in the cell of nitrogen fixing organism. What are the components in that enzyme molecule?
1) One protein part + iron
2) Two protein parts + molybdenum
3) Two protein parts + Iron + molybdenum
4) Two protein parts + Iron
27) Nitrogenase catalyses
1) Reduction of molecular nitrogen into ammonia
2) Oxidation of ammonia into nitrate
3) Oxidation of nitrate into nitrate
4) Conversion of nitrate into molecular nitrogen
28) Growth hormone secreted by the cortical cells, which are infected by Rhizobium to induce rapid cell division is
1) Cytokinin 2) IAA 3) Gibberellin 4) ABA
29) Reducing power required for reduction of dinitrogen into ammonia
1) $2e^{-,}$ $2H^+$ 2) $3e^-$, $3H^+$ 3) $6e^-$, $6H^+$ 4) $8e^-$, $8H^+$
30) Factor that is necessary for the functioning of nitrogenase which catalyses molecular nitrogen fixation
1) N_2 2) Mg^{+2}3) ATP 4) ATP + $2H^+$
31) The function of leghaemoglobin is
1) To supply oxygen to aerobic bacteria 2) To protect nitrogenase from oxygen
3) To assimilate N_2 4) To convert NO_3^- to N_2
32) The number of amino acids participating in protein biosynthesis is
1) 22 2) 20 3) 61 4) 64
33) The relationship between DNA, RNA and the sequence of aminoacids in a polypeptide chain is called

1) Transcription 2) Translation 3) Protein synthesis 4) Genetic code

34) Which component of DNA acts as a component in genetic code?
1) Deoxyribose 2) Nitrogen base 3) Phospahte 4) Nucleoside

35) Number of nitrogen bases present in a codon is
1) 4 2) 3 3) 61 4) 64

36) Number of triplets coding for all 20 amino acids is
1) 64 2) 61 3) 3 4) 22

37) The property of genetic code where "No single base can take part in the formation of more than one codon" indicates that
1) Code is degenerative 2) Code is non ambiguous
3) Code is universal 4) Code is non-overlapping

38) Initiation codon is
1) AUG/GUG 2) UAA/UAG 3) UGU/UGA 4) UAC/UCA

39) Initiation of codon AUG indicates which amino acid
1) Tryptophan 2) Lysene 3) Methionine 4) Leucine

40) Termination codons are
1) UAA, UAG, UCA 2) UAC, UGA, UAA
3) UAA, UAG, UGA 4) AUG, GUG, GUC

41) Total number of codons in the genetic code is
1) 20 2) 64 3) 16 4) 3

42) In Biosynthesis the product formed from the genetic code of one gene (cistron)
1) For one aminoacid only 2) For one enzyme molecule
3) For one protein molecule 4) For one polypeptide chain only

43) If the genetic code is a doublet code, how many codons can be formed?
1) 4 2) 16 3) 20 4) 64

44) No single base of m-RNA can take part in the formation of more than one codon. Hence, genetic code is described as
1) Commaless 2) Non-overlapping 3) Non-ambiguous 4) Degenerte

45) A particular code on in the genetic code will always code for the same amino acid. So it is
1) Universal code 2) Non-ambiguous code 3) Degenerate code 4) Commaless code

46) In the genetic code, a particular codon-codes for a particular amino acid in all kinds of living organisms. So it is said to be
1) Non-ambiguous code 2) Non –overlapping code
3) Universal code 4) Both 1 & 3

47) The correct sequence in protein synthesis is
1) DNA→Amino acids→ RNA→ Protein
2) DNA→RNA→Amino acids→Protein
3) Amino acids→DNA→RNA→Protein
4) RNA→DNA→Amino acid→Protein

48) The first amino acids in any polypetide chain in all prokaryotes is
1) Methionine 2) Leucine 3) N-Formyl methionine 4) Serine

49) Site of transcription in eukaryotes is
1) Nucleus 2) Cytoplasm 3) Vacuole 4) Ribosomal surface

50) Enzyme catalysing transpiration is
1) RNA polymerase 2) Peptidyl transferase
3) Amino acyl tRNA synthetase 4) DNA polymerase

Keys

1)2	2)3	3)1	4)2	5)3
6)4	7)1	8)3	9)4	10)2
11)2	12)4	13)1	14)2	15)1
16)2	17)1	18)2	19)3	20)4
21)1	22)3	23)3	24)2	25)1
26)3	27)1	28)2	29)4	30)4
31)2	32)2	33)4	34)2	35)2
36)2	37)4	38)1	39)3	40)3
41)2	42)4	43)2	44)2	45)2
46)4	47)2	48)3	49)1	50)1

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3) Two protein parts +iron +molybdenum 4) Two protein parts + Iron

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1) 4 2) 3 3) 61 4) 64
36) Number of triplets coding for all 20 amino acids is
1) 64 2) 61 3) 3 4) 22
37) The property of genetic code where "No single base can take part in the formation of more than one code" indicates that
1) Code is degenerative 2) Code is non ambiguous
3) Code is universal 4) Code is non-overlapping
38) Initiation codon is
1) AUG/GUG 2) UAA/UAG 3) UGU/UGA 4) UAC/UCA
39) Initiation codon AUG indicates which amino acid
1) Tryptophan 2) Lysene 3) Methionine 4) Leucine
40) Termination codons are
1) UAA, UAG, UCA 2) UAC, UGA, UAA
3) UAA, UAG, UGA 4) AUG, GUG, GUC
41) Total number of codons in the genetic code is
1) 20 2) 64 3) 16 4) 3
42) Assertion: m RNA is required for protein synthesis
Reason: DNA never enters the cytoplasm to give genetic information
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true
43) Assertion: Code is degenerate code
Reason: Genetic code is a triplet code
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true
44) Assertion: Azolla is used as biofertilizer
Reason: Azolla shows symbiosis with Anabaena
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false

4) A is false but R is true

45) Assertion: UAA, UAG and UGA are called terminating codons
Reason: RF1 and RF2 recognise the terminating codons
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

Keys

1)2	2)3	3)1	4)2	5)3	6)4	7)1
8)3	9)4	10)2	11)2	12)4	13)1	14)2
15)1	16)2	17)1	18)2	19)3	20)4	21)1
22)3	23)3	24)2	25)1	26)3	27)1	28)2
29)4	30)4	31)2	32)2	33)4	34)2	35)2
36)2	37)4	38)1	39)3	40)3	41)2	42)2
43)2	44)1	45)2				

Phytohormones
(Plant Growth Regulators)

1) Phototropism is canary grass coleoptile was first discovered by
1) Darwins 2) Went3) Skoog 4) Kurasawa

2) "The power of movements in plants" was published by
1) Boysen & Jensen 2) Palla
3) Charles Darwin & Francis Darwin 4) F.W. Went

3) Phototropic movement exhibited by coleoptile of canary grass was first observed and recorded by
1) Boysen – Jensen 2) F.W. Went 3) Paal 4) Charles Darwin

4) Organic substances which are synthesised in one part of the plant and function at a different part at a very low concentrations are called
1) Phytohormones 2) Auxins 3) Gibberellins 4) Cytokinins

5) Auxins were first isolated from the tip of coleoptiles of *A*vena sativa by
1) Darwin 2) Paal 3) Went4) Skoog

6) The first group of hormone identified and characterised in plant kingdom by Paul & Went is
1) Auxins2) Gibberillins 3) Cytokinins 4) Ethylene

7) Identify the in-correct statement about auxins
1) Higher or even moderate auxin concentration inhibits root growth
2) Auxins are responsible for apical dominance
3) Auxins in high concentration favour the formation of more female flowers in Cucurbits
4) Auxins promote Dormancy

8) Supression of growth of auxillary buds by actively growing terminal bud is called
1) Bolting 2) Apical dominance 3) Pruning 4) Topping

9) *A*vena coleoptiles exhibit phototropism, when exposed to unilateral light is due to
1) More rate of growth on the light exposed side
2) Less rate of growth on the light exposed side

3) More concentration of auxins on the exposed side
4) Less concentration of auxins on the shaded side

10) The auxin which is produced in shoot apex, moves down and accumulates in axillary buds to cause apical dominance. This was experimentally proved by
1) Skoog and Miller 2) Thimann and Skoog
3) Yabuta and Sumuki 4) Went & Paul

11) Auxin which is proved to be highly efficient in the induction of roots on stem cutting is
1) IAA 2) NAA3) IBA 4) 2, 4 –D

12) The ability of auxins to induce parthenocarpic fruit development was first observed in
1) Orachids 2) Pine apple 3) Cucurbits 4) Citrus

13) When rich plants are infected by the fungus *G*ibberella fujikuroi, the plants become
1) stunted & thicker 2) taller & thinner
3) dwarf & pale 4) bushy and more tillering

14) Who reported that the ‘Bakanae’ disease is due to something secreted by a fungus called Gibberella fujikuroi?
1) Yabutta 2) Sumuki 3) Sawada 4) Noll

15) The harmone isolated from the rice plants infected by ‘foolish seeding’ disease is
1) Auxins 2) ABA3) Gibberellins 4) Cytokinins

16) Gibberellic acid was obtained in crystalline form from the Gibberella fujikuroi by
1) Beadle and Tatum 2) Skoog and Miller 3) Burg and Gane 4) Yabuta and Sumuki

17) Gibberellins induce seed germination
1) Stimulating growth of embryo 2) Mobilising reserve food materials
3) Breaking the seed coats 4) Synthesizing food materials for growth of embryo

18) Sudden and rapid increase in length of shoot in rosettle plants like cabbage and cauliflower just before flowering is called
1) Richmond – Lang effect 2) Bolting 3) Parthenocarpy 4) Rosette formation

19) Coconut milk is used for the first time to induce cell division in tissue culture studies by
1) J.von Overbeek 2) Haberlandt 3) Burg 4) Miller

20) Kinetins were first isolated from yeast DNA by
1) G.Haberlandt 2) J.von Overbeek 3) Skoog & Miller 4) Miller & Letham

21) Zeatin was extracted and crystallized from immature maize seeds independently by
1) Miller & Letham 2) Skoog & Miller 3) Garner & Allard 4) Calvin & Benson

22) Benzylaminopurine (BAP) and Benzyladenine (BA) are the
1) Synthetic cytokinins
2) Substituted adenine compounds
3) Substrates that can induce cell division in tobacco pith tissue and carrot root secondary pholem
4) All the above

23) Naturally occuring cell division inducing phytohormones found in vascular tissue of many plants, coconut milk, immature maize grains are
1) ABA, Ethylene 2) Auxins 3) Cytokinins 4) Gibberellins

24) Cytokinins cause remarkable increase in size of soyabean leaves and radish cotyledons by promoting
1) Cell elongation 2) Cell division 3) Cell maturation 4) Cell wall permeability

25) Cytokinins delay the senescence and keep plant parts healthy and green. This property of cytokinins is called
1) Bolting 2) Richmond – Lang effect 3) Geotropism 4) Apical dominance

26) ABA is present in high concentration in

1) Dormant seeds, buds and senescent leaves
2) Dormant buds, cotyledons and root tip
3) Senescing leaves, stem tips & cotyledons
4) Young embryo, roots, cotyledons

27) Old leaves turn yellow and fall off due to formation of abscission layer which is induced by
1) ABA 2) Auxins 3) Ethylene 4) Auxins

28) The triple response growth in plants which involves inhibition of elongation, induction of lateral growth and transverse geotropism is the characteristic feature of
1) Cytokinins 2) Gibberellins3) ABA4) Ethylene

29) Leaf abscission and flower senescence are promoted by
1) Ethylene 2) Auxin 3) GA_3 4) Cytokinins

30) Dicotyledonous weeds in cereal crops, lawns and pastures are eradicated by the application of herbicidal auxins namely
1) 2, 4 – D and 2, 4, 5 – T 2) Zeatin 3) Ethylene 4) GA_3

31) A preharvest foliar application of which hormone enhance the shelf-life of leafy vegetables (spinach, lettuce, *A*sparagus) and vase-life of flowers
1) Auxins 2) Gibberellins 3) Cytokinins (BAP) 4) ABA

32) Prolonged latex of rubber and decrease of nicotine content of Tobacco are achieved by application of
1) Auxins 2) Gibberellins 3) Cytokinins 4) Ethylene

33) Cholodny – Went theory explains
1) Nastic movements 2) Tropic movements
3) Triple response growth 4) Tactic movements

34) Differentiation of callus in tissue culture requires a specific ratio of two hormones
1) Gibberellin & ethylene 2) Auxin & gibberellin
3) Gibberellin & cytokinin 4) Auxin & cytokinin

35) Abscisic acid contains
1) 19 or 20 carbons 2) 15 carbons 3) 2 carbons 4) 40 carbons

36) First isolated adenine derivative of phytohormone from green plants is
1) Zeatin 2) Kinetin 3) Benzyladenine 4) IBA

37) The Bioassay for auxin is
1) Avena coleoptile curvature test
2) *Phalleris canariensis* (Celesy grass) curvature test
3) Cell division test in tobacco pith cells
4) α - Amylase synthesis in barley seeds

38) Hedge plants grow bushy if one following is done
1) Axillary buds are removed 2) Application of auxins to lateral buds
3) Removal of Terminal buds 4) Placing the plants horizontally

39) Cytokinins can be used to increase the antibiotic production in Streptomyces bacteria. The principle involved is
1) Stimulation of cell division 2) Stimulation of cell expansion
3) Delay of senescence 4) Morphogenesis

40) Identify the incorrect statement about cytokinins
1) They are synthesised in the root system
2) They translocate from root system to shoot system
3) They are abundantly present in embryonic tissues
4) They help in the closing of stomata

41) Identify the incorrect statement about ethylene

1) It accelerates ripening of fruits in apple
2) It prolongs the latex flow in rubber
3) It prevents leaf abscission
4) It improves the colour of coffee berries

42) Excurrent stem showing apical dominance needle – like phylloclades, dry sorosis and cortical Vascular bundles and a true erophyte in which root nodules containing nitrogen fixing actinomycete Frankia is
1) Alnus 2) Casuarina 3) Eucalyptus 4) Mygrica

43)

List –I	List –II
A) Auxins	I) Addicot, etal
B) Cytokinins	II) Yabuta
C) Abscisic acid	III) F.W.Went
D) Gibberellin	IV) Skoog & Miller

The correct match is

	A	B	C	D
1)	I	III	IV	II
2)	III	IV	I	II
3)	I	IV	III	II
4)	II	III	I	IV

44)

Phytohormone	Scientist	Organism from which isolated
I) IAA	F.W.Went	**Avena sativa**
II) GA	Yabutta	Rice plant
III) Zeatin	Letham	Maize
IV) ABA	R.Gane	**Acer**

The correct match is
1) I & II 2) I & III 3) II & III 4) III & IV

45) Abscisic acid is absent in
I) Seeds II) Roots III) Buds IV) Bacteria
1) I & IV are correct 2) I & II are correct
3) II & III are correct 4) III & IV are correct

46) Study the following table:

Phytohormone	Scientist	Chemical nature	Physiological effect
I) Auxin	Addicot etal	Indole acetic acid	Apical dominance
II) Gibberellin	Yabuta & Sumiki	Diterpenoids	Bolting & flowering
III) Cytokinins	Skoog & Miller	Aminopurines	Morphogenesis
IV) Abscisic acid	F.W.Went	Sesquiterpnoids	Buds & seed dormancy

The correct combinations are
1) I & II 2) II & III 3) III & IV 4) II & IV

47) Match the following:

List – I	List –II
A) Auxin	I) Richmund – lang effect
B) Gibberellin	II) Senescence and abscission
C) Cytokinin	III) Removal of genetic dwarfism
D) Ethylene	IV) Root initiation
	V) Dormancy of buds and seeds

The correct match is

	A	B	C	D
1)	IV	III	I	II
2)	IV	III	II	I

3) III IV I II 4) II III IV V

48) Assertion: Auxins cause apical dominance
Reason: Detopping allows the growth of axillary buds
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

49) Assertion: Superior quality malt is obtained from germinating seeds treated with gibberellin
Reason: α - amylase production is due to gibberellins
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

50) Assertion: Shelf life of leafy vegetables can be enhanced by preharvest application of BAP on flower
Reason: Cytokinins delays scenescence
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

51) Assertion: Unripe fruits ripen when a ripened fruit is kept along with them
Reason: Ethylene is a fruit ripening hormone released from ripe fruit
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

52) Assertion: Coconut milk proliferation of pith tissues during tissue culture
Reason: Cytokinins promote cell division
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

53) Assertion: IAA is a common natural auxin in plants
Reason: Zinc is required for IAA synthesis
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

54) Assertion: Cytokinins induce opening of stomata
Reason: Abscisic acid induces closing of stomata
1) A and R are true and R is the correct explanation of A
2) A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

55) Auxins were discovered by
1) Addicot & wearing 2) Skoog & Muller
3) F.W.Went 4) Burg & Thimann

56) The bioassay for auxins is
1) Avena curvature test 2) Richmond – Lang effect

3) Triple response growth 4) α - amylase test

57) A synthetic auxin is
1) Indone 3 – acetic acid 2) 4 –chloro indole acetic acid
3) Phenyl acetic acid 4) Napthelene acetic acid

58) 2, 4 –D, 4, 5 –T are used in killing
1) Fungi 2) Dicot weeds 3) Monocot plants 4) Bacteria

59) The precursor amino acid for IAA synthesis is
1) Metheionine 2) Valine 3) Serine 4) Tryptophan

60) The micronutrient essential for the synthesis of auxins (IAA) is
1) Mo 2) Mg 3) Zn 4) Cu

61) The site of more auxin synthesis is
1) axillary buds 2) shoot apex 3) root apex 4) floral buds

62) The effect of auxins on cell elongation is seen in
1) excised stems 2) excised leaves 3) excised flowers 4) pollen grains

63) The auxin that is more efficient in including root initiation in low concentration in stem cuttings is
1) IAA 2) PAA 3) 4 – chloro IAA 4) IBA

64) Cholodny – Went theory explains
1) Root formation in stem cuttings 2) Shoot formation in callus
3) Cell differentiation into xylem
4) Tropic movements in different directions of plant axis

65) Supression of axillary buds by auxins is due to
1) low concentration of auxins 2) high accumilation of auxins in axillary buds
3) transport of auxins outside axillary buds
4) low concentration of auxins in the apical bud

66) Apical dominance can be removed by
1) cutting apical bud 2) bleaching auxins by chemicals
3) explosing stem apex to sunlight 4) exposing stems to cold temperatures

67) Formation of stamens in cucurbits is prevented by
1) Gibberellins 2) Auxins 3) Cytokinins 4) Ethylene

68) Parthenocarpic fruits in Orchids is due to
1) auxins 2) GAs 3) ABA4) Cytokinins

69) Foolish seedling disease of rice is due to this substance
1) cytokinins 2) gibberellins 3) auxins 4) ABA

70) The asexual stage of Gibberella fujikuroi is
1) Colletotrihum 2) Pyrucularia 3) Sphacelotheca 4) Fusarium moniliformae

71) Gibberellic acids with 19 carbons are
I) GA_1 II) GA_2 III) GA_3 IV) GA_7
1) Except I 2) Except II 3) Except III 4) Except IV

72) Genetic dwarfism can be removed by application of
1) NAA 2) IBA 3) 2, 4 –D 4) GAs

73) Seedless fruits of grapes and tomato are obtained by applying
1) Auxins 2) Ethylene 3) ABA4) Gibberellins

74) 6 –furfuryl amino purine is
1) Coconut milk 2) Milk of corn 3) Kinetin 4) Zeatin

75) Cytokinins were discovered by
1) Skoog & Miller 2) Darwin 3) F.W.Went 4) Addicot

76) The cytokinins present in the corn milk is
1) Kinetin 2) BA 3) BAP 4) Zeatin

77) The major function of cytokinins is
1) Morphogenesis 2) Cell division 3) Cell expansion 4) delay in senescence
78) Sesquiterpene compound is
1) C_2H_4 2) IAA 3) ABA 4) NAA
79) Phytohormone produced from all parts of the plant is
1) ABA 2) C_2H_4 3) IAA 4) BA
80) Stress harmone is
1) BA 2) Kinetin 3) ABA 4) Ethylene
81) Triple response growth is due to
1) C_2H_4 2) CH_4 3) ABA 4) GA_7
82) Flowering is delayed by
1) C_2H_4 2) IAA 3) BA 4) Kinetin
83) Leaf abscission and flower senescence are induced by
1) NAA 2) GA_7 3) Ethylene 4) ABA
84) Wound healing is induced by
1) ethylene 2) ABA 3) Kinetin 4) Zeatin
85) Colour of coffee berries can be improved by
1) ethylene 2) NAA 3) BAP 4) GA_6
86) Auxins are formed
1) In large quantities at stem tip and less at root tip
2) In less quantity at stem tip and more at root tip
3) In equal quantity at stem tip and root tip
4) None
87) Apical dominance means
1) Supression of growth of apical bud by axillary bud
2) Supression of growth of bud by axillary bud
3) Stimulation growth of apical bud by removal of axillary bud
4) Inhibition of growth of axillary bud by apical bud
88) 2, 4 –Dichloro phenoxy acetic acid is generally used as
1) Fungicide 2) Pesticide 3) Wormicide 4) Weedicide
89) Gibberellins produce
1) Curvature of coleptile 2) Root initiation
3) Internodal elongation 4) Cell division
90) The phytohormone which induces internodal elongation in an intact plant is
1) Gibberellic acid 2) Indole acetic acid 3) Cytokinin 4) Abscisic acid
91) Common activity of enzymes, vitamins and hormones is
1) Regulation of metabolism 2) Regulation of reproduction
3) Regulation of respiration 4) None of the above
92) An efficient root inducing chemical useful in horticulture
1) GAA 2) IBA 3) NAA 4) 2, 4 – D
93) ABA is involved in
1) Dormancy of seeds 2) Root elongation
3) Shoot elongation 4) Increased cell division
93) An efficient root inducing chemical useful in horticulture
1) Dormancy of seeds 2) Root elongation
3) Shoot elongation 4) Increased cell division
94) Hormone involved in phototropism is
1) IAA 2) GA 3) Cytokinin 4) ABA
95) The morphogenetic property of cytokinin was first experimentally proved by

1) Hanning2) Guha & Maheswari 3) Skoog & Miller 4) Went

96) Which of the following type of phytohormones resemble the nuclei acids in some structural aspects?
1) Cytokinins 2) Auxins 3) Gibberellins 4) Abscisic acid

97) Wareing and his co-workers were associated with the discovery of
1) Abscisic acid 2) Auxins 3) Cytokinins 4) Gibberellins

98) 'Richmond –Lang Effect' Deals with
1) Parthenocarpic fruit formation by auxins
2) Foolish seeding disease by gibberellins
3) Delay in senescence by cytokinins
4) Closure of stomata by abscisic acid

99) Natural auxins are synthesized from the amino acid
1) Methionine 2) Glycine 3) Lysine 4) Tryptophane

100) Example of positive geotropism is
1) Closing of flowers 2) Upward growth of stem
3) Downward growth of root 4) Lateral growth of root

Keys

1) 1	2) 3	3) 3	4) 1	5) 3	6) 1	7) 4	8) 2	9) 4	10) 2	11) 3
12) 1	13) 2	14) 3	15) 3	16) 4	17) 2	18) 2	19) 1	20) 3	21) 1	22) 4
23) 1	24) 2	25) 2	26) 1	27) 1	28) 4	29) 1	30) 1	31) 3	32) 4	33) 2
34) 4	35) 2	36) 1	37) 1	38) 3	39) 1	40) 4	41) 3	42) 2	43) 2	44) 2
45) 4	46) 2	47) 1	48) 3	49) 1	50) 1	51) 1	52) 1	53) 2	54) 2	55) 3
56) 2	57) 4	58) 2	59) 4	60) 3	61) 2	62) 1	63) 4	64) 4	65) 2	66) 1
67) 2	68) 1	69) 2	70) 4	71) 2	72) 4	73) 4	74) 3	75) 1	76) 4	77) 2
78) 3	79) 2	80) 3	81) 1	82) 1	83) 3	84) 1	85) 1	86) 1	87) 4	88) 4
89) 3	90) 1	91) 1	92) 2	93) 2	94) 1	95) 3	96) 1	97) 1	98) 3	99) 4
100)3										

UNIT –IX
MICRO BIOLOGY

- The branch of botany which deals with study of invisible microorganisms which can't be seen with our naked eye is called microbiology
- Algae, fungi, bacteria, virus, protozoans are studied under microbiology
- Micro organisms are seen with the help of electron electroscope
- Roger Stainer describe that microorganism can also be defined in term of techniques like streligation, culture media etc
- Louis Pasteur perform swam neck flask experiment and proved that microorganisms are carried by dust particles
- The beer & wine are spoiling due to growth of unwanted microorganisms
- Louis discovered the pasterization technique to prevent spoilage of beer & wine
- Father of microbiology – Louis Pasteur
- Louis Pasteur discovered vaccine for rabbies
- Microorganism are uniquotes i.e.; cosmopolitan
- Microorganism are found on or in living organism, leather air water, soil, wood sulphur springs, ice, snow
- Microorganism is divided into basic & applied microbiology
- Basic microorganism deals with morphology, Physical, Anatomy, Taxonomy & genetics of microorganism
- Applied microbiology deals with the beneficent and
    1) Industrial microbiology
    2) Public health microbiology
    3) Immunology microbiology
    4) Plant microbiology

<u>Bacteria</u>:

- They are microscopic, unicellular, prokaryotic organism
- Bacteria was discovered by Anton, Von-leuwenhock & called Themas animal cule
- The term bacteria was coined by Ehren Berg
- Bacteria is placed under protista by Earnest Haeckel
- Bacteria is placed under Monera by R.H. Whittaker
- By seeing the mode of reproduction by fission, bacteria is placed under schizomycetes
- Bacteria are unbiquotes
- Bacteria living on ice are called Psychrophilic
- Bacteria present at Sulphur springs are called Thermophilic
- Bacteria can't survive in salt due to plasmolysis & die
- Endosymbiont (or) Colon bacillus (or) Human intestine bacteria is E.coli
- Bacteria is placed under protophyta by Bargey
- Famous book on bacteria is Bergey's manual of determinative bacteriology Walkman
- Father of microbiology is Louis Pasteur
- Louis Pasteur prepare vaccine for Rabbies
- Nitrogen fixing free living aerobic bacteria is Azotobacter
- Nitrogen fixing free living anerobic bacteria is clostridium
- The bacteria commonly engaged in nitrification process is Bacillus
- The bacteria commonly engaged in genetic engineering experiments is Eicoli

- Abortions in domestic animals is due to Salmonella species
- Bacteria don't reproduce in atmosphere but atmosphere acts as reservoir
- Polluted water contain more number of bacteria than fresh water
- One gram of normal soil contains $10^6 – 10^7$ bacteria
- Bacteria cell size ranges from 0.5 – 1.0μ & 2 – 5μ in length
- Smallest Kn bacterium is pasturella
- Largest Kn bacterium discovered in intestine of brown sturgeon fish is Epulosicum fishelsoni which is rod shaped
- Recently discovered largest bacteria in the coast of Namibia is thiomargariate Namibiensis. Which is spherical shape
- Bacteria are of various shape like
  1) Spherical shape – Cocci
  2) Rod shape – Bacillus
  3) Coma shape – Vibrio
  4) Spiral - Spirallum
- Single spherical shaped bacteria is Mono Coccus
- 2 spherical shaped bacterium – Diplo Coccus
- 4 spherical shaped bacterium – Tetra Coccus
- A group of spherical shaped bacterium arranged irregularly – Stapylo Coccus
- A group of spherical shaped bacterium arranged in the form of cube of eight is Sarcina
- A chain of spherical shaped bacterium is Strepto Cocus
- Single rod shaped bacterium is mono bacillus
- 2 rod shaped – Diplo bacillus
- Vibrous & Spirellum don't exist in groups
- Bacterium may be thread like (or) filament like is Beggiota
- Some bacteria can change its shaped due environment & nutrients such bacteria are called pleomorphic bacteria which exhibit plemorphism ex: Acetobacter

<u>Structure of Bacterial Cell</u>:

- It resembles a typical prokaryotic cell
- It resembles plant cell in having cell wall
- Cell wall is made up of Murein (or) Peptidoglycons (or) Micropolysaccherides.
- The cell wall of gram +ve bacteria shows thecoic acid which is absent in gram –ve bacteria
- Cell wall consisting of imp amino acid called diamino pimelic acid
- Cellulose is absent in cell wall of bacteria
- The bacterial cell consisting of 3 layers; they are cell wall, plasma membrane, slime layer
- Capsule protects the cell from dessication & Phagocytosis
- Capsule is consumed during starvation by bacteria
- Plasma membrane is semi permeable (or) differentially permeable
- In some gram +ve bacteria the plasma membrane shows infillings in cytoplasm called merosomes
- Merosomes helps in formation of daughter cell, Chromosomal replication increase the absorption of nutrients
- Mesosomes helps in formation of daughter cell, chromosomal replication, increase the absorption of nutrients
- Mesosomes found in Prokaryotes perform apparatus found in Eukaryotes

- Bacteria shows whip like appendages called flagella which are extending oue of cytoplasm & plasma membrane
- Flagella is made up of protein called flagellin
- Bacteria flagella doesn't show (9+2) arrangement but shows (4+4) arrangement
- Diameter of flagella - 120 A^0
  Length of flagella – 4- 5μ
- Bacteria swims in water with the help of flagella
- Bacteria rotates in water with the help of flagella
- Depending upon number of flagella & distribution of flagella the bacteria are classified into
  1) Ateichous – flagella absent ex: Pasturella
  2) Monotrichous – Flagella absent ex: Pasturella
  Lophotrichous – A tuft of flagella on one side of cell ex: Vibrios
  4) Amphitrichous – A tuft of flagella on the both the sides of cell ex: Nitrosomonas
  5) Peritrichous – flagella present on all over the body surfacery ex: E.Coli
- Sex pilli are the long appendages (tube like) which helps in bacteria conjugation for binding two conjugants
- Pilli is made up of protein called pillin (or) fimbrilin
- Pilli is called fimbriae
- The genetic material present in bacterial cell is called nucleside (or) genome (or) genophore
- Circular, double stranded DNA is present in bacterial cell
- Number of Chromosomes is L (bacteria)
- Histone protein are absent in bacterial cell
- The self replicating naked Double standed DNA (or) extra – chromosomal DNA present in bacterial cell is called Plasmid (or) F Factor
- Plasmid helps in
  1) Carrying the genes for drug resistance
  2) New metabolic path ways
  3) delective advantage to bacterial cell
- E.Coli with 'F' factor is called F^+ cell (or) Donar cell (or) male cell
- E.Coli cells lacking 'F' factor are called F^- cell (or) acceptor cell (or) receipient cell (or) female cell
- 'F' factor means fertility factor
- The proto plasm consisting of genetic material in bacteria is called Nucleoid
- All double membrane cell organelles like endoplasmic reticulum, mitochondria, chloroplast, golgi complex etc are absent
- Bacteria consisting of 70s type of ribosomes (50s + 30s)
- Ribosomes helps in respiration
- Absorptions in domestic animals occurs due to Salmonella species
- Bacillus – Saprophyte
- Parasite – Xanthomonas, Salmonella
- Symbionts – Rhizobium & E.coli
- True Sexual reproduction is absent in bacteria
- Sexual reproduction takes place by genetic recombination
- In bacteria, sexual reproduction takes by endospores & fission
- Binary fission is the common method during favourable condition
- Binary fission takes place for every 18 –20 minutes
- For every fission number of cells will be double

- Cocci divides in all planes
- Bacilli, Vibrio, Spirillum divides longitudinally
- Endospores are formed during unfavourable conditions like dry & nutrient deficient conditions
- Endospores are very common in Bacillus & Clostridium
- Endospores in bacteria may present at centre (or) terminal (or) sub terminal
- Endospores consists of DNA, RNA & Cytoplasm
- The dense Cytoplasm of endospores is covered by spore wall
- Cortex – spore coat - exosporium
- Endospores are highly resistance & dominant spores
- Cysts are formed in bacteria like Azoto bacter
- Bacteria like Actinomyces, Streptomyces reproduce asexually by conidia (or) Arthospores
- Most rapid method of multiplication in bacteria is binary fission
- Primitive method of reproduction is sexual
- Karyogamy & Meiosis don't occur in bacteria
- Genetic recombination (or) Sexual reproduction takes place by transformation, conjugation, transduction
- Transformation – Alfred Griffith in Streptococcus Pneumonia (inside the body of Rat)
- Transformation is the uptake of naked DNA molecule by a bacterial cell in incorporation with its receipient chromosome
- Transformation is seen in bacteria living in soil & marine environment
- Natural transformation has been discovered in bacteria like Streptococcus, Pseudomonas, Acetobacter
- Conjugation was discovered by Tatum and Lederberg
- Transfer of genetic material through direct cell to cell contact is known as conjugation
- E.coli shows tow mating types
  1) F^+ x F^- 2) HFR x F^-

<u>Mating between F^+ x F^-</u>:

- Here F^+ get attach to F^- cell with the help of Sex pilli (or) Fimbria
- F^+ transmit 'F' factor to the cytoplasm of F^- through conjugation tube
- After conjugation F^- becomes F^+
- Progeny obtain from F^- bacteria are called recombinants
- The strains of E.Coli in which 'F' factor is integrated with the Chromosomes are called HFR (or) Super Males

<u>Mating between HFR & F^-</u>:

- HFR get attach with F^- with the help of pilli where conjugation tube is formed between them through this, a little part of 'F' factor enter into F^- cell
- Mating between HFR & F^-, the F^- remains as F^- but never become F^+ (because whole part of 'F' factor is not transferred
- Transduction – Laderberg & Zinder in Salmonella typimuriem
- The transfer of genetic material from one bacterium to another bacteria through bacterio phage is called transduction
- Transduction occurs during Cytic & Cysogen cycles of virus
- Transduction is also called Phage mediator transfer of genetic material

- Microbiology is the study of invisible microorganisms (micro = very small, invisible; bios = living; logos = study of discourse. It is often defined as the study of organisms that are too small to be seen by the unaided eye and can observe only with the help of microscope.
- Algae, fungi, protozoa, bacteria and viruses etc are studied under microbiology
- According to Roger Stainer (1978) microbiology may be defined not only in terms of the size of its objects but also in terms of the techniques that are used for culture
- Techniques like sterilization and these of culture media are necessary for successful isolation and growth of micro organisms
- Micro organisms are ubiquitous (omni present) in our environment. They are found in a number of habitats wherever moisture and nutrients are available and can also be found in soil, mud, water, air, animals, plants, food products, dead wood, clothes, leather, optical instruments, nails, skin, etc
- Micro organism can tolerate acidic conditions, alkaline conditions and salt concentrations. Micro organisms which can tolerate acidic conditions are known as acidophilic organisms. Micro organisms which can tolerate alkaline conditions are known as alkalophilic organisms. Microbiology has great impact on medicine, agriculture industry and environment . Microbiology has basic and applied aspects

Microbiology

Basic Microbiology	Applied Microbiology
(It deals primary with Morphology, Cytology, Ecology in Genetics Taxonomy of Micro Organisms)	(It is concerned with beneficial and harmful activities of micro organism in relation to man and their exploitation and control) i) Medical microbiology (deals with diseases of man & animals) ii) Pubic health microbiology prevention and control of diseases) iii) Agricultural microbiology (impact of micro organisms on agriculture) iv) Environmental microbiology (effect of publication on micro) v) Food microbiology (deals with spoilage of food, borne diseases etc

Some Important Events in Microbiology:

Scientist	Investigation	Year
Leeuwenhoek	Simple microscope and describing invisible organisms	1676
Edward Jenner	Vaccination for small pox	1798
Louis Pasteur	Disapproval of spontaneous generation theory	1861
Joseph Lister	Antiseptic surgery	1867

Robert Koch S,N.Winogradsky M.Beijerinck Karl Land Steiner Charles Laveran Paul Ehr F.d & F.W, Twort Alexander Fleming Alexander Fleming N.Ruska WM.Stanley F.C, Bawden& N.W, Pirie Beadle & Tatum S.A.Waksman J.Lederberg & E, L.Tauni F.P. Rous H.M.Temin G,J.F.Kohler & C.Milsten R,C,Gallo & L.Montagriler J.M.Bishop & H.E.Varmus Stanley Pruisener	Koch Postulates and culturing of bacteria Study of Iron and sulphur bacteria Isolation of root nodule bacteria and virus particle Causing tobacco mosaic disease Blood groups Role of protozoa in disease Chemotherapeutic agents Bacteriophages Penicillin Electron microscope Crystallization of TMV Nucleoprotein nature of TMV One gene – one enzyme hypothesis Discovery of streptomycin Bacterial conjugation Bacterial transduction Discovery of cancer virus Discovery of reverse transcriptase Monoclonal antibodies Isolation and Identification of HIV Discovery of oncogenes Prions	1884 1890 1888 1892 1902 1907 1910 1917 1929 1933 1935 1937 1941 1944 1946 1952 1966 1970 1975 1984 1989 1998

- Louis Pasteur (trench biochemist) did important pioneering contribution for the basic and applied microbiology
- Louis Pasteur proved that micro organisms are carried out by dust particles by his famous swan necked flask experiments
- He proved that spoilage of beer and wine is due to growth of undesirable micro organisms
- To prevent spoilage of beer and wine (is due to growth of undesirable micro organisms) pasteurization method was developed
- Pasteur developed the vaccine against – chicken pox, cholera and rabies
  For his contributions to microbiology Pasteur is aptly regarded as “Father of Microbiology”

BACTERIA

- Bacteria were discovered by Leeuwenhoek
- Leeuwenhoek called bacteria as wild animalcules
- The term bacterium was proposed by Ehrenberg
- Study of bacteria bacteriology
- Louis pasture, Robert Koch laid foundations for bacteriology
- Bacteria were studied in detail by Louis Pasteur, Robert Koch. Nageli, Cohen & Gram
- Germ theory of disease was proposed by Louis Pasteur
- Most extensively studied bacterium is E.coli
  1) Bacteria are omnipresent
  2) Bacteria living on ice are called psychrophilic
  3) Bacteria living at hot

- The bacterium common in intestine of man and mammals is E.coli. It is a facultative anaerobic organism
- Cohn classified bacteria based on their shape
- Round – shaped bacteria are called cocci (singular – coccus)
- Rod – shaped bacteria are called bacilli (singular – bacillus)
- Spiral – shaped bacteria are called spirillis (spirillum singular)
- Comma – shaped bacteria are called vibrio
- If coccus bacterium occurs singly, it is called micro or monococus
- If coccus bacterium occurs in pairs it is called diplococcus
- A chain of cocci bacteria is called streptococcus
- Cocci bacteria occurring in the form of bunch of grapes – staphylococcus
- A cubical arrangement of 8 cocci is called – sarcina
- Bacilli also exist as monobacillus diplobacillus & steptobacillus
- Spirilli and vibrios do not occur in groups
- Frequent change in shape of certain bacteria is called pleomorphism
- Basing on no and distribution of flagella, the types of bacteria are
- Monotrichos one flagellum at one pole
- Lophotrichous – A tuft of flagella at one pole
- Amphitrichous – two tufts of flagella at two poles
  (one tuft of flagella at each pole)
- Peritrichous – flagella a throughout the surface of the bacteria cell
- Atrichous – No flagella
- Flagella are absent in cocci bacteria
- Diameter – 0.5 – 2u
- Length – 1 – 10u
- The length of spirillum is 500u
- The staining method useful for bacteria is gram staining devised by Christian Gram
- Reagent used in gram staining is crystal violet (gentian violet)
  a) Bacteria treated with crystal violet attain blue colour when immersed in iodine solution
  b) When these bacteria are washed with ethyl alcohol, some retain blue colour and some become colourless
  c) Bacteria which retain blue colour are called gram +ve
  d) Bacteria which lose it are called gram–ve
  e) Bacteria which retain blue colour are called gram +ve
  f) Bacteria which lose it are called gram -ve
- Bacteria's are unicellular micro organisms
- Bacteria's are prokaryotes (true nucleus is absent)
- Bacteria's are having three cellular layers these are
  i) Slime layer ii) Cell wall iii) Plasma membrane
- Mucilage is secreted by the plasma membrane
- Capsule is useful for protecting the cell from desiccation
- Capsule is digested and consumed by cell during starvation
- Bacteria are considered as plants due to the presence of cell wall
- Cellulose is absent in the cell wall
- Cell wall of bacterium is made up of mucopeptide. (Peptidoglycan or murein)

- Mucopeptide is a polymer of
  1) NAM – N – acetyl muramic acid
  2) Nag – n –acetyl gulucosamine (NAM, NAG, ARE AMINO SUGARS OF GLYCAN PROTON)
  3) Polypeptide contains 4 amino acids (L –alanine, d-alanine, D-glutamic acid, lysine)
- Important amino acid present in cell wall of bacterium is diaminopimilic acid (Gram + ve bacteria)
- Plasma membrane is made up of phospholipids and proteins
- PM is differentially permeable. Respiratory enzymes are present on PM (Plama membrane)
- Cell organelle formed due to the in folding of plasma membranes mesosome
- Nuclear material of bacterial cell is called nucleiod or Genophore or genome
- Number of chromosomes presenting a bacterial cell is 1
- Nucleoid or nuclear material contains circular DNA or snaked DNA
- Small rings of DNA present in the cytoplasm are called plasmids
- Type of 'ribosome' is present in a bacterial cell – 70s (50s, 30s)
- Reserve food materials are in the form of glycogen granules volutin granules
- Cell organelles absent in bacterial cell are mitochondria, GC<ER, plastids, vacuoles
- Type of protein present in pilus is pilin. Pili are present in donors
- Pili are useful for attachment during conjugation. They are called sex pili as they participate in sexual reproduction
- Type of protein present in flagellum of bacterium – flagelin
- Nutrition: based on their mode of nutrition bacteria are classified into two types
  1) Autotrophic
  2) Heterotrophic
- Bacteria which can synthesize organic substance form simple inorganic substance are called autotrophic bacteria
- A few bacteria are autotrophic, Autotrophic bacteria's are of few types
  1) Photosynthetic
  2) Chemosynthetic
- Photosynthetic bacteria convert CO_2 into carbohydrate in the presence of light
- The bacteria commonly engaged in nitrification bacillus
- Nitrosomonas is concerned with reduction of nitrate to nitrite
- Plasmids are extra chromosomal circular DNA material
- Milk is concerned into curd by lactobacillus lactis
- Germ theory of disease was proposed by Louis Pasteur
- Bacteria living on ice are called psychrophilic
- Bacteria living on ice are called psychrophilic
- Bacteria living at hot springs (sulphus) thermophilic
- Bacterial commonly present in intestine and mammals is E.coli. It is facultative anaerobic organism
- Generally gram – ve bacteria are pathogenic and posses capsule
- Capsule is digested and consumed by bacterial cell during starvation
- Important amino acid present in cell wall of bacterium is Diaminopimillic acid
- Number of chromosomes present in bacterial cell is one
- Reserve food materials are stored in two forms

1) Glycogen con p^{HB}
2) Polyhydroxyl Buterate

- Pili are present in donors
- Denitrifying bacteria are thiobacillus denitrificans and pseudomonas denitrificans
- Bacterium which acts as parasite on another bacteria is bdellovibrio bacteriovorus. It purifies the water of rivers oceans
- E.coli is commonly known as colon bacilococcus
- The bacterium which is widely used in genetic experiments is E.coil
- Parasitic bacteria which is used in the presence of host are called obligate parasites.
- Free living nitrogen fixing aerobic bacterium is azotobacters
- Free living nitrogen fixing anaerobic bacterium is clostridium
- Gram + ve bacteria are generally resistant to antibiotics
- In grace the bacteria the cell wall consists of one layer which is equal to murin
- Gram – ve bacteria the cell wall is make of two layers (Lipopolys aceharides inner – Murein)
- Haemophiles influenza, protens vulgalis, vibrio cholera salmonella typhi acid E.coli are gram – ve bacteria
- Diplococcus pheacouliar, streptococcus pyogenes, staphylococcus gureces are gram +ve bacteria
- According to robinow, the cell wall plays a important role in cell division
- In bacteria Mesosomes are found which do not functions of Golgi apparatus found in eukaryotic cells
- Bacteria flagella do not show 9+2 configuration. Acid differs from eukaryotic cell.
- Rotation of flagella help the bacteria to swim in the water
- Gram – ve bacteria have short hair like appendages called pili (or) fimbrial.
- Sex pili help in bacterial conjugation by binding the two conjugant
- All memberane bound cell organelles are basement
- Purple and green photosynthetic bacteria are free floating forms volcanic irruption called gas varnobes
- The region of protoplasm consists the genetic material is called nucleoid
- In nucleoid the nucleus membrane acid **nucleus** absent
- DNA is circular acid double stranded
- In some bacteria an a additional self replicating small circular naked double standard DNA is present known as plasmid (or) F factor
- Plasmids carry genes for dry resistance, new metabolic pathway and new pathogenic ability and give bacteria a selective advantage
- Bacteria was placed under Prophyta by Bergey
- Bacteria were killed heating at $50^0 – 60^0$C (pasteurization)
- A bacterium grow through different phases of growth such as lag, exponential, stationary and death phase
- Hf male $\rightarrow$ super male
- Actinomyces is the mycelial bacterium
- Length of bacterial flagellum ranges between 4 –5 aμ
- Diameter of the bacterial flagellum range between $120A^0$
- Size of bacterial ribosome is $100A^0$
- The term microbe was first used by se dillot
- Caulobacters is the stalked bacterium
- Flagellum is almostly entire made up of proteins

- The anthrax bacteria are covered by a coat of polypeptides
- Bacteria flagellum shows 4+4 arrangement
- The process of destroying all living organisms is called sterilization
- Mutation in bacteria was discovered by Detbruck and Luria
- Pasteurization of milk involves heating for 30min at about 65^0C
- The term polio was earlier coined by mycoplasmas
- Klebsiella occurs symbiotically in the leaf nodules of Pavetta
- Abortion in domestic animals occurs due to the feeding of Salmonella species
- Mycoplasmas were discovered by Nocard and Rolx
- The site of respiration in bacteria is Ribosome
- Bacteria differs from virus in having cytoplasm
- Saprophytes – Bacillus
- Parasites – xanthomonae, salmonella
- Symbionts – Rhizobium, E.coli
- Bacteria posses a Chlorophyll called chlorophyta
- In bacteria the sexual reproduction takes place by binary fission & endospores
- Binary fission is common method during favourable conditions
- Binary fission takes place for every 18 –20 minutes
- For every fission, the number of cells is doubled
- Cocci divides in all planes
- Bacilli, vibrios and spirillum divides longitudinally
- Endospores are formed during unfavourable conditions like dry and nutrient deficient Conditions
- Endospores are very common in Bacillus and clostridium
- Endospores in bacteria may present as terminal sub terminal central
- Endospores consists of DNA and cytoplasm
- The dense cytoplasm covered by spore wall, covered by cortex →spore coat→exosporium
- Endospores are highly resistant and dormant spores
- Cysts are formed in bacteria like Azotobacters where wall consists of thick exine and intine
- Bacteria like actinomyces and streptomyces reproduce asexually by conidia (or) arthropores
- Myxospores are present in gram + bacteria like myxococcus
- Binary fission is most rapid method of multiplication in bacteria
- Sexual reproduction in bacteria is primitive
- True sexual reproduction is absent in bacteria
- Karyogamy and meiosis do not occur in bacteria
- Sexual reproduction by genetic recombination, in bacteria
- Transformation, Transduction and consignation
- True sexual reproduction is absent in bacteria
- In bacteria, the sexual reproduction take place genetic recombination
- In bacteria sexual reproduction takes by transformation, conjugation and transduction
- Karyogamy and meiosis do not occur in bacteria
- Transformation was discovered Alfred Griffith in streptococcus pneumoniae-inside the body of rats
- Transformation is the uptake of naked DNA molecule by a bacterial cell and the incorporation with recipient chromosomes
- Transformation seen in bacteria living soil & Warm environments

- Natural transformation has been discovered in bacteria like streptococcus, Pseudomonas, Azotobacter bacillus
- Conjugation was discovered by Ledberg & Tatum in E.coli
- The transfer of genetic material through direct cell to cell contact is known as conjugation
- E.coli show two mating types
- Cell taking fertility factor (f –factor) is called F + (or) donor cell (or) male cell
- Cell taking fertility factor (f – factor) is called f (or) acceptor cell (or) female cell
- F+ gets attached to F- with the help of pili (or) fimbriae
- F + cell transmit the t factor to the cytoplasm of acceptor cell (F-cell) through conjugation tube
- After conjugation the F-becomes F + cell
- F + bacterium dies after conjugation
- F – bacterium is partly diploid and is merolggote
- Progeny obtained from F- bacterium are called recombinants
- The strains of E.coli in which the f fact is integrated with the chromosome are called after strains (or)
- Transduction was discovered by Eherenberg and zender in Salmonella typhimurium
- The transfer of genetic material from one bacterium to another bacterium through bacteriophages
- Transduction occurs during lytic and lysogenic cycles of bacteriophageses
- Transduction is otherwise known as phase mediated transfer of genetic material
- Bacteria are considered as friends and foes of man
- Bacteria help in Biogeochemical cycle hence they are called scavenger of nature
- A bacterium useful for extracting antibiotics like stretomycin auremycin, terramycin is streptomyces
- Scientist who was awarded noble prize for discovering streptomycin is Wakman
- World's famous microbiologist is Wakman
- Bacteria play a significant role in maintaining soil fertility
- Bacteria which converts protein, amino acids of dead bodies into a ammonia are called ammonifying bacteria and the process is called ammonification
  Ex: Bacillus
- Bacteria which converts ammonia into nitrates are called nitrifying bacteria and the process is called Nitrification
  Ex: Nitrobacter & Nitrosomonas
  (Nitrobacter converts nitrites into nitrates)
  (Nitrosomonal oxidizes Ammonia into Nitirites)
  Bacillus thuringensis is used as Bionsecticide against insect pesta
- The bacteria which helps in extracting fibers from sun hemp are clostridium bestyricum & clostridium felcinium
- Methanobacilus and ethanococcus bacteria ferment the cow dung anaerobicallya produce methane gas that is commonly called as 'Gobar gas'
- Chemicals compound produced by bacteria

Chemical	***Bacteria***
Acetone, Butanol	Clostridum acetobutylium
Vinegar	Acetobacter aceti
Lactic acid	Lactobacillus delbruckii

Propionic acid	Propionibacterium proplonum
Ethanol	Zymomonas mobiles

- Species of streptomyces and bacillus produce important antibiotics
- The bacteria that produce the important amino acid Lysine is corynebacterium glutamicum

Antibiotics	***Bacterium***
Streptomycin	Streptomyces grisecut
Chloram phenicol	S.Venezular
Neomycin	S.Fradiae
Kanamycin	S.Kanamycelilus
Amphotericin	S.Nodosus
Polymyxin B	Bacillus Polymyta
Bacitracin	B.licheniform's

- Insulin harmone is produced from E.coli with the help of recombinant DNA technology.
- Single cell protein (Slip) are produced from bacteria like brevipactum
- Bacterium which is used as vector in genetic engineering is agrobacterium tumefascieus
- Bacteria like Staphylococcus, Pseudomonas, Salmonella, Elicococcus, Clostridium causes spoilage of food materials
- Clostridium botulinum produces potential toxin while growing on food material. This is known as botulism a type of food material. This is known as botalism

A type of food poisoning:

Blight of rice	X. anthomonas oryzae
Angular leaf spot	X. manucacearum
Citrus canker	X. citri
Wilt of potato plant	Pseudomonas solanacerum
Crown gall of apple and peal	Agrobacterium tume faswear
Fire blight of apples	Erwinia

Animal diseases:

Anthrax of sheep	Bacillus anthracis
Tuberculosis of dogs & cattle	Mycobacterium tuberculosis
Actinomycosli of cattle	Mycobacterium baxis
Laboriosin	vibro tetus

Human diseases:

Dystentery	Bacillus dysentery
Diphtheria	Coryne bacterium dipththeriae
Cholera	vibrio cholera
Typhoid	Salmonella typhi
Pneumonia	Diplococeus Pneumoniae
Tuberculosis	Mycobacterium tuberculosis
Leprosy	M.leprae
Plague	Pasteyrella pestis
Gonorrhea	Neisseria gonorrhoea
Tetanus	clostridium tetani

VIRUS

- Virus are nucleoprotein particles
- Virus are smaller than bacteria

- A cellular, sub microscopic entitles enclosed DNA (or) RNA in a protein coat-virus
- Virus can be observed under transmission & scanning electron microscope
- Louis Pasteur developed vaccine for Rabbies
- They had no motility, don't response to Stimulity
- Virus first discovered by Twanowski & called them fitterable agents
- The term virus was coined by Beijerinsck. He described them as contagium Vivum fluidum (or) living infectious fluid
- In latin, Virus – Poisonous fluid
- Chemical nature of virus was studied by Pierce & Bawden & demonstrated that virus made of Nucleic acid & protein
- Edward Jenner developed vaccine for small pox, without understanding nature of virus
- Cancer virus discovered by F.C ROUS
- HIV was discovered by R.C gallow & Mountagnier
- Virus are connecting link between living & non living organism

  Living Character:

  1) Presence of Nucleic acids & Proteins
  2) Capable of multiplying
  3) Infect Plants, Animal & human

  Non-Living Character:

  1) Small in size & ultramicroscopic
  2) Cellular Organization is absent
  3) Metabolic activity are absent
- Binary fission, mitosis, meiosis are absent in virus
- Virus are resistance to acids, alkalies & salts
- Virus are resistant to temperature upto 85^0C but ineffective above 85^0C
- Virus are inactivated by X-rays, mercury vapour lamps. When exposed above 1 hour
- 1% of $CuSO_4$ & 40% HCHO destroys the virus
- Virus that attacks bacteria – Phyto phages
- Virus that attacks fungi – Myco phages
- Virus that attacks Yeast – Zymo phages
- Virus that attacks blue green algae – Cyano phages
- Virus that attacks mammals – Mammalian Virus
- Virus that attacks animals – Zoophyages
- Smallest virus – bacteriophages F_2
- Largest virus – Vaccinia virus
- The shape of virus can be viewed through low power electron microscope
- Rod shaped ex: TMV
- Rectangular shaped ex: Vaccinia virus
- Polyhedral shaped ex: Adenovirus
- Spheriodial shaped ex: Poliovirus
- Tadpole shaped ex: Bacteriophages
- Bullet shaped ex: Rhapdovirus
- Virus shows two types of symmetry

  1) Helicle symmetry   2) Cubic symmetry

  Based on arrangement of Capsomere in capsid

- In helicle symmetry, the capsomere are hellically arranged around the core of Nucleic acid which resemble the spire stair cases ex: TMV
- In cubic symmetry, capsomeres are arranged in Iso sahedron symmetry each phase is an equilateral triangle & show 20 phases ex: Adeno virus
- T- even bacteriophages show binary symmetry which is the combination of helicle & cubic symmetry
- In T- even virus head shows cubic symmetry & tail show helicle symmetry
- Single particle of virus – Vision
  Which consisting of protein coat & nucleic acids
- The outer protein coat of virus is called capsid
- The protein coat which encloses nucleic acids are called nucleocapid
- Capside protects the virus nuclear material & helps its transfer between host cell
- The structure unit of capsid are called capsomere & protomers
- Virus consist of either DNA & RNA but not both
- Virus posses all kinds of nucleic acid like double stranded DNA, SS DNA,
  DS RNA & SS RNA
- Nucleic acids may be circular (or) Linear
- Bacteriophages, Zoophages, Zymophages, Cyanophages contain, DNA
- Always plant virus consist of RNA as genetic materials except cauliflower mosaic virus & Dahlia mosaic virus. (Plant virus are oval (or) rod shaped)
- Generally animal virus consisting of DNA except polio virus & influenza which consist of RNA
- DS DNA – Vaccinia & Herpes
- SS DNA – S –13, M –13, F –1, Par Vi Virus
- DS RNA – Rhe virus, wound tumor virus
- SS RNA – Polio virus, TMV
- Reed discovered - Yellow virus
- Smith discovered - Influenza virus
- Popper discovered – Polio virus
- Virus depend upon host since they lack Carbohydrates
- The most extensively studied plant virus is TMV
- TMV is rod shaped
- In TMV capsomeres are arranged in helical manner capsiel consist of 2130 capsomeres
- TMV consist of SS RNA i.n
- Virod – Nucleic acid only
- Prion – Protein coat only
- Dr.Y.Subba Rao discovered the antibiotic aurcomycin

Microbiology

Match the following Questions:

Ex –1

1) Applied microbiology that deals with the controlling of pollination, with the help of microorganisms is
   1) Public health 2) Microbial biotechnology
   3) Environmental microbiology (Microbial Ecology)
   4) Immunology
2) Industrial microbiology is not concerned with the production of
   1) Steroids 2) Vitamins 3) SCP 4) Amino acids
3) A branch of microbiology that deals with the production of SCP is
   1) Food microbiology 2) Microbial Ecology
   3) Immunology 4) Agricultural microbiology
4) Applied microbiology is concerned with
   1) Study of physiology of microorganisms
   2) Study of genetics of microorganisms
   3) Study of beneficial and harmful activities of microorganisms in relation to man
   4) Study of taxonomy of microorganisms
5) Identification and elimination of the agent that causes an infectious disease in humans and animals is the aim of
   1) Immunology 2) Medical microbiology
   3) Public health microbiology 4) Microbial ecology
6) Branch of applied microbiology that deals with the spread, prevention and control of communicable diseases is
   1) Medical microbiology 2) Public health microbiology
   3) Immunology 4) Microbial biotechnology
7) Practical health problems like nature and treatment of allergies and auto-immune diseases are related to
   1) Public health microbiology 2) Industrial microbiology
   3) Food microbiology 4) Immunology
8) Protection of the body from pathogens by antibodies can be studied under
   1) Medical microbiology 2) Immunology
   3) Public health microbiology 4) Basic microbiology
9) Effect of pollution on the microorganisms and redeeming of polluted environment with the help of microorganisms are studied under
   1) Environmental microbiology 2) Public health microbiology
   3) Microbial biotechnology 4) Medical microbiology
10) Identify, which is not related to Food microbiology?
    1) Spoilage of food materials 2) Food intoxications
    3) Production of Alcohols 4) Production of cheese and SCP
11) Industrial microbiology is not concerned with
    1) Production of valuable ores on commercial scale
    2) Production of antibodies and enzymes
    3) Production of pickles and mushrooms
    4) Production of steroids
12) Microbiology concerned with production of vaccines, vitamins, aminoacids
    1) Industrial microbiology 2) Immunology

3) Public health microbiology 4) Basic Microbiology
13) Food microbiology is not related to
1) Food borne diseases 2) Production of yogurt, pickles
3) Production of mushrooms 4) Production of penicillin
14) Which of the following deals with the microorganisms that cause diseases in crop plants and those that play beneficial role in enhancing soil fertility and crop yield
1) Medical microbiology 2) Agricultural microbiology
3) Industrial microbiology 4) Microbial ecology
15) With the advent of recombinant DNA technology and genetic engineering, microbiology is becoming weapon to solve the challenges in the field of
1) Ecology 2) Physiology 3) Biotechnology 4) Embryology
16) Bacteria were first observed and reported by
1) Robert koch 2) Leeuwenhoek 3) Louis Pasteur 4) Ehrenberg
17) Bacteria were described as "animalcules" by
1) Ehrenberg 2) Winogradsky 3) Leeuwenhoek 4) Robert koch
18) Whose detailed works highlighted the importance of Bacteria?
1) Louis Pasteur & Koch 2) Leeuwenhoek & Ehrenberg
3) Whittaker & Haeckel 4) Beijerinck & Stanley
19) Pathogenic nature of bacteria in case of plants, animals and human beings was observed by
1) Whittaker and Haeckel 2) Leeuwenhoek and Ehrenberg
3) Louis Pasteur and Koch 4) Beijerinck and Stanley
20) Microscope, unicellular, achlorophyllous or chlorophyllous organisms which can multiply by binary fission are
1) Bluegreen algae 2) Bacteria
3) Yeasts 4) Viruses
21) The group protista was created by
1) Whittaker 2) Haeckel 3) Sinnot 4) Margulis
22) The bacteria, algae, fungi and protozoa are included in Protista by
1) Haeckel 2) Whittaker 3) Sinnot 4) Margulis
23) Who divided all living organisms into five kingdoms. (Viz.Monera, Protista, Plantae, Fungi & Animalia)
1) Whittaker 2) Haeckel 3) Ehrenberg 4) Leeuwenhoek
24) Whittaker included bacteria and blue green algae in
1) Protista 2) Monera 3) Protozoa 4) Plantae
25) Bacteria and blue green algae are included in the Kingdom-Monera by
1) Louis Pasteur 2) Robert Koch 3) Haeckel 4) Whittaker
26) Bacteria are placed in a distinct group namely Schizomycetes based on
1) Mode of reproduction by fission
2) Mode of reproduction by fragmentation
3) Mode of Respiration
4) Mode of reproduction by death and decay of older parts
27) Bacteria can't multiply in
1) Salt water 2) Atmosphere 3) Soil 4) Ice
28) The bacterium that makes a mutually beneficial is association with roots of legume plants
1) *Escherichia* 2) *Rhizobium* 3) *Beggiota* 4) *Salmonella*
29) Escherichia coil present in the intestine of man is a
1) Parasite 2) Symbiont 3) Pathogen 4) None
30) Epulopiscium fishelsoni is

1) Rodshaped 2) Spherical 3) Spiral shaped4) Pasteurella

31) A huge bacterium which was discovered in the intestine of the brown surgeon fish is
1) Thiomargarita 2) Epulopiscium 3) Acetobacter 4) Pasteurella

32) Spherical bacterium is called
1) Spirilum 2) Vibrio 3) Bacillus 4) Coccus

33) Rod shaped bacterium is called
1) Bacillus 2) Cocci 3) Vibrio 4) Spirillum

34) Find out incorrect match
1) Sarcina: Cocci bacteria arranged in cube of eight
2) Streptococcus: A long chain of spherical bacteria arranged in a single row
3) Diplococcus: Spherical bacteria arranged in pairs
4) Monococcus: A single rod shaped bacterium

35) A group of cocci bacteria forming irregular shape is called
1) Staphylococcus 2) Streptococcus
3) Sarcina 4) None

36) 40 –Corkscrew shaped bacterium is
1) Bacillus 2) Coccus 3) Vibrio 4) Spirillum

37) Find out incorrect match
1) Monobacillus: A single rod shaped bacterium
2) Diplobacillus: Rod shaped bacteria arranged in pairs
3) Streptobacillus: A chain of rod shaped bacteria
4) Staphylobacillus: A group of round shaped bacteria forming irregular shapes

38) A single bacilloid bacterium is
1) Streptobacillus 2) Sarcina 3) Microbacillus 4) None

39) Coma shaped bacterium is called
1) Coccus 2) Bacillus 3) Vibrio 4) Spirillum

40) Spirillum is a
1) Cork screw shaped bacterium 2) Round bacterium
3) Comma shaped bacterium 4) Rod shaped bacterium

41) Bacteria which can change their shapes frequently are called
1) Bacteriods 2) Prions 3) Pleomorphic bacteria 4) Cyano bacteria

42) Acetobacter is a
1) Pleomorphic bacterium 2) Parasitic bacterium
3) Nitrogen fixing bacterium 4) Denitrifying bacterium

43) Prokaryotic cell structure is found in
1) Bacteria only 2) Blue green algae only
3) Virus 4) Bacteria and blue green algae

44) Bacterial cell wall is not made up of
1) Peptidoglycan 2) Murein 3) Mucopeptide 4) Cellulose

45) In bacterial cell wall peptides are attached to
1) Muramic acid 2) NAG3) Teichoic acid4) None

46) The shape of Thiomargarita namibiensis is
1) Rod shaped 2) Spherical 3) Spiral shaped4) Comma shaped

47) Glycocalyx which is tough and firmly attached is called
1) Slime layer 2) Capsule 3) S-layer 4) None

48) Glycocalyx which is present as loose sheath is called
1) Slime layer 2) Capsule 3) S-layer 4) None

49) Dry used by Christian Gram to stain bacteria is
1) Malachite green 2) Janus Green – B 3) Crystal viole 4) Acetocarmine

50) Popular staining techinque for bacteria was developed by
1) Lister 2) Louis Pasteur 3) Christian Gram 4) Ehrenberg

51) Peptidoglycans are
1) Reserve food material formed in bacterial cells
2) Special strains of viruses
3) Flagella material
4) Special wall material found in bacterial cells

52) Chromatium is
1) Purple sulphur bacteria 2) Green sulphur bacteria
3) Non-green sulphur bacteria 4) Carbon bacteria

53) Cell wall does not help the bacteria in
1) Providing definite shape 2) Protecting from osmolytic lysis
3) Protecting form toxic substance 4) Carbon bacteria

54) The site of action for antibiotics in a bacterias cell is
1) Capsule 2) Cell wall 3) Mesosome 4) Pili

55) The bacterium which is used to purify the water in rivers, Ganges
1) Xanthomonas 2) Bdellovibrio 3) Epulopiscium 4) Rhodospirillum

56) Bacteriophages were discovered by
1) Twort 2) Edward Jenner 3) N.W.Pierie 4) Giesrer

57) The bacteria which survive under the condition of p^H fluctuations have
1) Cell wall 2) Plasma membrane 3) Capsule 4) S-Layer

58) A regularly structured layer present outer to the cell wall in some bacteria is
1) Slime layer 2) Capsule 3) S-layer 4) Capsid

59) One of the following character is not common for both capsule and slime layer
1) Protect the cell from dessication
2) Protect bacteria from phagocytosis by host cells
3) Both are well organised
4) Both are composed of polysaccharides

60) One of the following structure contribute to the virulence of some pathogenic bacteria
1) S layer 2) Slime layer 3) Capsule 4) Capsid

61) Some bacteria protected against p^H fluctuations and osmotic stress with the help of
1) Slime layer 2) Capsule 3) S layer 4) Mesosome

62) Locomotory structures of bacteria are
1) Pili 2) Flagella 3) S-Layer 4) Cell wall

63) Non-motile bacteria of the following
1) All Cocci 2) All bacilli 3) All bacilli & cocci 4) Vibrous

64) Non-flagellated bacteria are called
1) Atrichous 2) Monotrichous 3) Lophotrichous 4) Peritrichous

65) Bacterium with only one flagellum is
1) Lophotrichous 2) Amphitrichous 3) Peritrichous 4) Monotrichous

66) Find out incorrect match from the following
1) Amphitrichous – a tuft of flagella on both ends
2) Amphitrichous – a single flagellum on both ends
3) Lophotrichous – a single polar flagellum
4) Peritrichous – Many flagella, all over the surface

67) Number of long coiled flaments made up of flagellin present in the flagellum of a bacterium is

1) One 2) Two 3) Three 4) Eleven
68) Flagella arise from
1) Messome 2) ER 3) Basal granules 4) DNA
69) Many gram negative bacteria provided with short, fine, hair like structures called
1) Pili 2) Flagella 3) Trichomes 4) Tubules
70) Fimbriae are made up of a special protein called
1) Flagellin 2) Pilin 3) Muramic acid 4) None

Keys

1)3	2)3	3)1	4)3	5)2	6)2	7)4	8)2	9)1	10)3
11)3	12)1	13)4	14)2	15)3	16)2	17)3	18)1	19)3	20)2
21)2	22)1	23)1	24)2	25)4	26)1	27)2	28)2	29)2	30)1
31)2	32)4	33)1	34)4	35)1	36)4	37)4	38)3	39)3	40)1
41)3	42)1	43)4	44)4	45)1	46)2	47)2	48)1	49)3	50)3
51)4	52)1	53)4	54)2	55)2	56)1	57)4	58)3	59)1	60)1
61)3	62)2	63)1	64)1	65)1	66)3	67)3	68)3	69)1	70)2

Ex-2

1) Bacteria were first observed and reported by
1) Robert koch 2) Leeuwenhoek 3) Louis Pasteur 4) Ehrenberg
2) Bacteria were described as “animalcules” by
1) Ehrenberg 2) Winogradsky 3) Leeuwenhoek 4) Robert koch
3) Whose detailed works highlighted the importance of Bacteria?
1) Louis Pasteur & Koch 2) Leeuwenhoek & Ehrenberg
3) Whittaker & Haeckel 4) Beijerinck & Stanley
4) Pathogenic nature of bacteria in case of plants, animals and human beings was observed by
1) Whittaker & Haeckel 2) Leeuwenhoek & Ehrenberg
3) Louis Pasteur & Koch 4) Beijerinck & Stanley
5) Microscopic, unicellular, anchlorophyllous or chlorophyllous organisms which can multiply by binary fission are
1) Blue green algae 2) Bacteria 3) Yeasts 4) Viruses
6) The group protista was created by
1) Whittaker 2) Haeckel 3) Sinnot 4) Margulis
7) The bacteria, algae, fungi and protozoa are ‘included in Protista’ by
1) Haeckel 2) Whittaker 3) Sinnot 4) Margulis
8) Who divided all living organisms into five kingdoms.(Viz.Monera, Protista, Plantae, Fungi & Animalia)
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1) Escherichia 2) Rhizobium 3) Beggiota 4) Salmonella
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1) Providing definite shape 2) Protecting from osmolytic lysis
3) Protecting from toxic substances 4) Synthesizing enzymes

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1) Capsule 2) Cell wall 3) Mesosome 4) Pili

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4) Both are composed of polysaccharides

45) One of the following structure contribute to the virulence of some pathogenic bacteria
1) S-layer 2) Slim layer 3) Capsule 4) Capsid

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52) Number of long coiled filaments made up of flagelin present in the flagellum of a bacterium is
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53) Flagella arise from
1) Mesosome 2) ER 3) Basal granules 4) DNA

54) Many gram negative bacteria provided with short, fine, hair like structures called
1) Pili 2) Flagella 3) Trichomes 4) Tubules

55) Fimbriae are made up of a special protein called
1) Flagellin 2) Pilin 3) Muramic acid 4) None

56) The main function of pili is
1) locomotion 2) absorption of food material
3) Attached bacteria to solid surface 4) To dissolve other bacteria

57) The infoldings of plasma membrane into cytoplasm in gram positive bacteria are called
1) Lomosomes 2) Glyoxysomes 3) Mesosomes 4) Chromatophores

58) The structure that helps in maintaining the turgidity and osmoregulation in bacteria cell is
1) Cell wall 2) Capsule 3) Plasma membrane 4) S-layer

59) The sub –units of bacterial ribosomes are
1) 50S & 40S 2) 50S & 30S 3) 60S & 40S 4) 60S & 30S

60) Nature of reserve food materials in bacteria is
1) Glycogen 2) Floridian starch 3) Proteins 4) Starch

61) Poly β-hydroxy butyrate (PHB) is a kind of
1) Wall material 2) Genone 3) Reserve food 4) Excretory substance

62) The main feature of chromatophores is
1) They are present in Eukaryotes only
2) They are present in chromoplasts
3) They are present in bacteria
4) They are not bounded by unit membranes

63) Number of chromosomes present in a bacterial cell
1) only one 2) two 3) many 4) four

64) Bacterial DNA is
1) Single stranded, circular 2) Single stranded, linear
3) Double stranded linear 4) Double stranded, circular

65) Nuclear material in bacteria is called
1) Nucleosome 2) Nucleoid 3) Karyosome 4) Z DNA

66) Some bacteria provided with plasmid genes which are responsible for
1) Drug resistance 2) new pathogenic abilities
3) Develop new metabolic pathways4) All the above

67) Additional ring of DNA present in some bacteria to normal nuclear material is called
1) Nuclein 2) Nucleoid 3) Nucleosome 4) Plasmid

68) One of the following is not a photoheterotroph
1) Rhodospirillum 2) Rhodopseudomonas
3) Chromatium 4) Rhodomicrobium

69) Non-sulphur purple bacteria are
1) Photo autotrophs 2) Photoheterotrophs
3) Chemo- autotrophs 4) Chemo-heterotrophs

70) Rhodopseudomonas is
1) Green sulphur bacteria 2) Non-green sulphur bacteria
3) Purple sulphur bacteria 4) Non-sulphur purple bacteria
71) Bacteria which get carbon from CO_2 and energy from oxidation of inorganic substances
1) Hydrogen bacteria 2) Nitrifying bacteria
3) Colourless sulphur bacteria 4) All the above
72) Colourless sulphur bacteria are
1) Photo-autotrophs 2) Photo heterotrophs
3) Chemo autotrophs 4) Chemo-heterotrophs
73) Rhodomicrobium is
1) Purple sulphur bacterium 2) Non-sulphur purple bacterium
3) Non-green sulphur bacterium 4) Green-sulphur bacterium
74) Microorganisms which grow at high salt concentrations are called
1) Halophilic 2) Acidophilic 3) Alkalophilic 4) Coprophilic
75) Saprophytic bacterium from the following is
1) Bacillus 2) E.Coli 3) Rhizobium 4) Xanthomonas
76) Parasitic bacterium from the following is
1) Xanthomonas 2) Salmonella
3) Mycobacterium 4) All the above
77) The bacteria which derive both carbon and energy from organic substances like glucose or aminoacides are
1) Chemo heterotrophic bacteria 2) Chemoautotrophic bacteria
3) Photo autotrophic bacteria 4) Photo heterotrophic bacteria
78) Non symbiotic nitrogen fixing bacteria among the following
1) Rhizobium 2) Frankia 3) Anabaena 4) Azatobacter
79) Binary fission takes place during
1) Favourable conditions 2) Unfavourable conditions
3) Mineral deficiency 4) Dry conditions
80) The most common type of reproduction in bacteria is
1) Conjugation 2) Binary fission 3) Transformation 4) Budding
81) Under favourable conditions the bacterium undergoes binary fission for every
1) 10 –20 minutes 2) 16 –20 minutes 3) 18 –20 minutes 4) 60 minutes
82) Viruses were discovered by
1) Beijerinick 2) Iwanowski 3) Stanley 4) Twort
83) Virology is the study of
1) Viruses 2) Virions 3) Viriods & Nucleocapsids 4) All the above
84) Non-viral disease from the following is
1) Rabies 2) Poliomyelitis 3) Yellow fever 4) Botulism
85) Completely eradicated viral disease
1) Small pox 2) Influenza 3) Polio 4) Rabies
86) Viral disease that threatening the mankind at present is
1) AIDS 2) Rabies 3) Polio 4) Yellow fever
87) First vaccine developed by Edward Jenner against which of the following disease
1) Hydrophobia 2) Small pox 3) Diphtheria 4) Typhoid
88) Louis pasteur developed vaccine against
1) Rabies 2) Polio 3) Hepatitis –B 4) Influenza
89) Who demonstrated that mosaic disease of tobacco is caused by filterable agents
1) Beijerinck 2) Iwanowski 3) Felix de Herelle 4) Rous
90) Who described viruses as ‘contagium vivumfluidum’ or ‘living infectious fluid’

1) Beijerinck 2) Iwanowski 3) Pierie 4) Rous

91) The distinct nature of virus was established by
1) Rous 2) Beijerinck 3) Gallow 4) F.C.Bawden

92) First crystallised virus was TMV, It was first crystalised by
1) W.M.Stanley 2) Pierie & Bawden 3) Sabina 4) Salk

93) Chemical nature of virus was given by
1) Delbruck 2) Andrew Lwoff 3) Pierie & Bawden 4) Twort

94) Who demonstrated that TMV was made up of proteins and RNA
1) Delbruck2) Pierie & Bawden 3) Twort 4) Andrew Lwoff

95) Bacteriophages were discovered by
1) F.W.Twort 2) Knoll & Ruska 3) Gellow & Montagnier 4) Rous

96) Obligate intracellular parasites are
1) Bacteria 2) Algae 3) Viruses 4) Fungi

97) The smallest virus is
1) Vaccinia virus 2) Herpes virus
3) Bacteriophage –f_2 4) Polio virus

98) The largest virus is
1) Adenovirus 2) Vaccinia virus
3) Polio virus 4) Herpes virus

99) Virus particles are known as
1) Viroids 2) Prions 3) Virions 4) Bacteriophages

100) Vaccinia virus is
1) Rectangular virus 2) Polyhedral virus
3) Rod shaped virus 4) Spheroidal virus

101) An example of polyhedral virus
1) Polio virus 2) Adenovirus 3) Rhabdovirus 4) TMV

102) Bullet shaped virus is
1) Rhado virus 2) Mumps virus 3) ORF virus 4) Poliovirus

103) TMV is a
1) Rectangular virus 2) Polyhedral virus
3) Spheroidal virus 4) Rod shaped virus

104) Find out the incorrect match of the following
1) Bacteriophages – Tadpole shaped 2) Polio virus – Spheroidal
3) Adeno – Bullet shaped 4) Adenovirus – Polyhedral

105) Among tadpole shaped viruses, structure was clearly studied in the case of
1) T-even series phages 2) T-odd series phages
3) Phages that show lysogenic cycle 4) None

106) A virus with helical symmetry is
1) Adenovirus 2) TMV 3) T_2-Phage 4) Coliphage -λ

107) Cubic symmetry is present in
1) T_2-Phage 2) Adenovirus 3) Citrus exocortosis virus 4) None

108) Icosahedron has
1) 20 faces 2) 16 faces 3) 8 faces 4) Many faces

109) In icosahedron each face is an equilateral
1) Triangle 2) Quadrangle 3) Pentangle 4) None

110) Type of symmetry in T_2 and T_4 Bacteriophages is
1) Helical 2) Cubical 3) Binal4) None

111) Most of the animal viruses provided with an outer envelope enclosing the nucleocapsid
1) Capsid 2) Capsule 3) Peplos 4) Prions

112) Sub units of peplos are called
1) Viroids 2) Prions 3) Peplomers 4) Capsomeres

113) Study the following table:

Process	Scientist	Organism
I) Gram's staining process	Christian gram	Siprogyra
II) Transformation	Alfred Griffith	Streptococcns pneumoniae
III) Conjugation	Beedle & Tatum	Escherichia coli
IV) Transduction	Leaderberg & Zinder	Salmonella typhimurium

Which tow taxa shows the correct combination?
1) II & III 2) II & III 3) III & IV 4) II & IV

114) Study the following table:

Bacteria	Host	Diseare
I) Xanthomonas oryzae	Betulism	Blignt
II) Pasturella pestris	Denitrification	Plague
III) Treponema pallidum	N_2 fixation	Syphilis
IV) Bacillus anthracis	Retting	Anthrax

Which two taxa shows the correct combination?
1) I & II 2) I & III 3) II & IV 4) I & IV

115) Study the following table:

Virus	Shape	Symmetry
I) Adeno	Polyhedral	Helical
II) Vaccinia	Bullet	Cabic
III) T.M.V	Rod	Helical
IV) T_2 bacterio phage	Tadpole	Binal

Which two taxa shows the correct combination?
1) I & II 2) II & III 3) III & IV 4) II & IV

116) Match the following:

List –I	List –II
A) Medical microbiology B) Immunology C) Industrial microbiology D) Microbial ecology	I) Production of vaccines, steroids, enzymes, etc II) Redeeming of pollnted environments with the help of micro biology III) Production of cheese yorgult IV) Nature of cause of allergies V) Identifying the agent causing disease liable to transmitt

1) A-IV, B-V, C-III, D-I 2) A-I, B-II, C-III, D-V
3) A-V, B-IV, C-I, D-II 4) A-IV, B-V, C-I, D-II

117) Assertion: Purple sulphur bacteria obtain energy from sunlight and carbon from the atmospheric carbondioxide
Reason: All bacteria are photautotrophs
1) A is correct but R is wrong
2) A is wrong but R is correct
3) A and R are true and R is the correct explanation of A
4) A and R are true and R is not the correct explanation of A

118) Assertion: Potato leaf roll disease is transmitted through insects
Reason: Pollen grains are involved in the transmission of rice tungro disease
1) A is correct but R is wrong

2) A is wrong but R is correct
3) A and R are true and R is the correct explanation of A
4) A and R are true and R is not the correct explanation of A

119) Assertion: After bacterial conjugations between Hfr and F^- the recipient remains as F^-
Reason: When Hfr bacterium participates in conjugation 'F' plasmid is not transferred to the receipent.
1) A is correct but R is wrong
2) A is wrong but R is correct
3) A and R are true and R is the correct explanation of A
4) A and R are true and R is not the correct explanation of A

Keys

1)2	2)3	3)1	4)3	5)2	6)2	7)1	8)1	9)2	10)4
11)1	12)2	13)2	14)2	15)1	16)2	17)4	18)1	19)4	20)1
21)4	22)4	23)3	24)3	25)1	26)3	27)1	28)4	29)4	30)1
31)2	32)2	33)1	34)3	35)3	36)4	37)1	38)4	39)2	40)2
41)1	42)4	43)3	44)1	45)1	46)3	47)2	48)1	49)1	50)1
51)3	52)3	53)3	54)1	55)2	56)3	57)3	58)3	59)2	60)1
61)3	62)4	63)1	64)4	65)2	66)4	67)4	68)3	69)2	70)4
71)4	72)3	73)2	74)1	75)1	76)4	77)1	78)4	79)1	80)2
81)3	82)2	83)4	84)4	85)1	86)1	87)2	88)1	89)2	90)1
91)2	92)1	93)3	94)2	95)1	96)3	97)3	98)2	99)3	100)1
101)2	102)1	103)4	104)3	105)1	106)2	107)2	108)1	109)1	110)3
111)3	112)3	113)4	114)4	115)2	116)3	117)1	118)1	119)3	

UNIT –X
GENETICS

1. The word gene was coined by W. Johannsen in 1909. A gene is a physical and functional unit of heredity. It carries information from one generation to the next. Gene is also defined as a nucleotide sequence that is responsible for the production of a specific protein.
2. When a gene undergoes changes due to mutation, it results in biological variations. These variations are important for evolution. Such variations also arise due to recombination of genes on chromosomes.
3. The relationship between genes and enzymes was discovered by Beadle and Tatum. They conducted bio-chemical research on the fungus Neurospora and concluded that the major role of genes was to carry information for the production of enzymes. For their work they were awarded Nobel prize in 1958.
4. Their findings are referred to as 'one gene one enzyme hypothesis'. Now, the hypothesis has been modified to 'one gene one polypeptide hypothesis' because the product of gene action is always a polypeptide.
5. Genome may be defined as the totality of the DNA sequences of an organism including DNAs present in mitochondria and chloroplasts. Each species has a characteristic number of chromosomes in the nuclei of its gametes and somatic cells. The gametic chromosome number constitutes a basic set of chromosomes of the organism. In all organisms it is made up of DNA but in viruses, it is made up of either DNA or RNA.
6. In human genome, 38.2% of genome is involved in biochemical activities like synthesis of immunological and structural proteins, 23.2% in the maintenance of genome, 21.1% in receiving and giving signals related to cellular activities and remaining 17.5% in the general functions of the cell. The functions of 30,000 to 40,000 human genes are known.

Linkage and crossing over

- The tendency of genes or characters to be inherited together because of their location on the same chromosome is called linkage. Many hybridization experiments were conducted both on plants and animals based on Mendel's work. The results of certain dihybrid crosses did not confirm the law of independent assortment. It states that the inheritance of genes of each pair in a dihybrid during gamete formation is independent of the other.

Mechanism of linkage - coupling in Lathyrus odoratus

- In 1906, William Bateson and Reginald Punnett conducted experiments in sweet pea, Lathyrus odoratus to confirm Mendel's dihybrid testcross. They observed an exception to the independent assortment of two genes in this plant. Here, blue flower (B) is dominant over the red flower (b) and long pollen (L) dominant over round pollen (l). They crossed true breeding plants having blue flower with long pollen (BBLL) and red flower with bl

Crossing over

- The process, which produces recombination of genes by interchanging the corresponding segments between nonsister chromatids of homologous chromosomes, is called crossing over. A crossing over between linked genes allows their recombination during meiosis.
- Crossing over takes place in pachytene stage of prophase I of meiosis. In pachytene stage, the bivalent chromosome becomes tetrad i.e. with four chromatids. The adjacent nonsister chromatids are joined together at certain points called chiasmata. Crossing over occurs between the nonsister chromatids of paired chromosomes in the region of chiasma. At each chiasma, the two nonsister chromatids break, exchange their segments and rejoin resulting the crossing over.

Hence, out of four chromatids the two adjacent chromatids are recombinants and other two are original chromatids. Thus four types of gametes are obtained. Significance of crossing over m Crossing over leads to the production of new combination of genes and provides basis for obtaining new varieties of plants. m It plays an important role in the process of evolution. m The crossing over frequency helps in the construction of genetic maps of the chromosomes. m It gives us the evidence for linear arrangement of linked genes in a chromosome.

Gene mapping

- Genes are arranged linearly in a chromosome. The point in a chromosome where the gene is located is called locus. The diagrammatic representation of location and arrangement of genes and relative distance between linked genes of a chromosome is called linkage or genetic map. The unit of genetic map is Morgan or centimorgan. When the percentage of crossing over between two linked genes is 1 per cent, then the map distance between the linked genes is one morgan. There is a greater probability of occurrence of crossing over, when the two genes are farther apart in a chromatid. The probability of crossing over between two genes is directly proportional to the distance between them.

Uses of gene mapping

- It is useful to determine the location, arrangement and linkage of genes in a chromosome.
- It is useful to predict the results of dihybrid and trihybrid crosses.

Recombination

- The process, which produces recombinations of gene by interchanging of corresponding segments between nonsister chromatids of homologous chromosomes, is called recombination of chromosomes. It takes place in pachytene stage of prophase I of meiosis. Crossing between the linked genes results in genetic recombination.
- According to Bateson and Punnet, in Lathyrus odoratus 12 per cent of the test cross progeny were recombinants. Recombination between two genes is expressed

in percentage. It is called recombination frequency. Gene pairs that had very low percentage of recombination are known as tightly linked genes.

- The gene pairs with higher percentage are termed as loosely linked genes.

Mutation

- In a species, variations are caused by changes in the environment or any changes in the innate genetic setup of an organism or by the combination of both. Sudden change in the genetical set up of an organism is defined as mutation.
- In 1901, Hugo de Vries first used the term mutation based on his observation on Oenothera lamarckiana. Charles Darwin termed these sudden change as ‘sports’. According to Bateson, mutation is a discontinuous change.
- Based on molecular basis of heredity, mutation is defined as sudden change in the sequence of nucleotides of gene. The mutation brings about a change in the organism. The organism which undergoes mutation, is called a mutant. eg. Oenothera lamarckiana.
- Mutations that affect the biochemical reactions are called biochemical mutations. For example, biochemical mutants of Neurospora failed to synthesize certain amino acids. Some mutations drastically influence the genes and cause death to the individual. Such mutation is described as lethal mutation. For example, in the plant Sorghum, recessive mutant fails to produce chlorophyll and therefore they die in the seedling stage.

Thus, most of the mutations are harmful, because they disturb the genic balance of the organism. Although most of the mutations are useless and even harmful, and some of the mutations play a significant role in the evolution of new species. Many new strains of cultivated crops and new breeds of domesticated animals are the products of gene mutations. Small seeded Cicer arietinum (bengal gram) suddenly get mutated to large seeded Cicer gigas is the case of gene mutation.

Classification of mutation

Mutations have been classified in various ways based on different criteria. Depending on the kind of cell in which mutations occur, they are classified into somatic and germinal mutation. They may be autosomal or sex chromosomal according to their type of chromosome in which they occur. They may be spontaneous or induced according to their mode of origin. They may be forward or backward according to their direction.
They may be dominant or recessive according to their phenotypic expression of mutated genes.

Point or gene mutation

- Point mutation is sudden change in small segment of DNA either a single nucleotide or a nucleotide pair. Gross mutation is a change involving more than one or a few nucleotides of a DNA.
- The gene mutation may be caused by loss or deletion of a nucleotide pair. This is called deletion mutation and reported in some bacteriophages
- Addition of one or more nucleotides into a gene results in addition mutation. Replacement of certain nitrogen bases by another base in the structure of DNA

results in substitution mutation. The deletion and addition mutation alter the nucleotide sequence of genes and ultimately result in the production of defective protein and this leads to the death of the organism.
- The substitution mutations can alter the phenotype of the organism and have great genetic significance.

There are two types of substitution mutations – transition and transversion. When a purine or a pyrimidine is replaced by another purine or pyrimidine respectively this kind of substitution is called transition.

When a mutation involves the replacement of a purine for pyrimidine or viceversa this is called transversion.

Mutagenic agents

The chemical substances and environmental conditions which cause mutations in the organisms are called mutagens or mutagenic agents. There are two kinds of mutagenic agents – physical and chemical mutagenic agents.

Physical mutagenic agents

Electromagnetic radiation, radiations like a, b and g, ultraviolet rays, temperature, etc. are some of the examples for physical mutagens. X-rays and gamma rays are ionizing radiations which induce mutation in seeds. UV rays are nonionizing radiations. Pollen can be treated with UV since pollen has germinal nucleus in which mutation can be caused.

Chemical mutagenic agents

Chemicals can also be used for inducing mutations in the organisms. Such chemicals are called chemical mutagenic agents.
eg. Nitrous acid, Methyl methane sulphonate (MMS) and ethyl methane sulphonate (EMS). Ethyl methane sulphonate has been extensively used for inducing mutations in microorganisms, higher plants and animals.

Significance of mutation

- Mutations play an important role in the origin of new species and serves as a tool for evolution.
- Induced mutations are useful in agriculture, animal husbandry and biotechnology to produce new strains. For example, mutant strains of Penicillium produces more penicillin.
- It is one of the best approaches for improvement of crops.
- Induced mutants are reported in paddy, wheat, soyabeans, tomatoes, oats, and barley. Mutant varieties of wheat are early maturing, disease resistance and they are enriched with protein. Mutant varieties of paddy produce many tillers with long grains.
- The study of mutant strains of viruses helps us to know the fine structure of gene.

- The genes are made up of small functional units such as cistron, recon and muton. Cistron is an unit of function, recon is the unit of recombination and muton is the unit of mutation.
- Many types of mutations cause heritable diseases and cancer in human beings.

Chromosomal aberrations
In an organism, any visible abnormality in chromosome number or structure from the diploid set is known as chromosomal aberration. The chromosomal aberrations based on the structure of the chromosome are of four types – deletion, duplication, inversion and transversion.

Structural chromosomal aberrations
Deletion

- The loss of a segment of the genetic material in a chromosome is called deletion. It may be terminal or intercalary. When the deletion occurs near the end of the chromosome, then it is called terminal deletion.
  Eg. Drosophila and Maize. When the deletion occurs in the middle of the chromosome then, it is called intercalary deletion. Most of the deletions lead to death of an organism.

Duplication

- When a segment of a chromosome is present more than once in a chromosome then, it is called duplication.

Inversion
It is another chromosomal abnormality in which, the order of genes in a chromosomal segment is reversed by an angle of 180°.

There are two types of inversion – pericentric and paracentric inversion.

- In pericentric inversion, the inverted segment of the chromosome contains centromere. Sometimes, it is responsible for evolution of the organism.
  For example the 17_{th} human chromosome is acrocentric, while in Chimpanzee the corresponding chromosome is metacentric.
- In paracentric inversion, the inverted segment of the chromosome has no centromere.

Translocation
It is a kind of a chromosomal abnormality in which the interchange of the chromosomal segments occurs. When translocation occurs between two non-homologous chromosomes, then it is called reciprocal translocation

UNIT –XI
MOLECULAR BIOLOGY

The phosphorus rich giant molecules present in the nucleus are called nucleic acids
The biochemical activites leading to growth and development of organisms are caused by Nucleic acids
Joseph Fredrick Meischer (Swiss Scientiest) discovered the nucleic acids in the nuclei of pus cells
Altman coined the term 'nucleic acid'
The nuclei acidsare two types namely
1) DNA 2) RNA

DNA (Deoxyribo Nucleic Acid)

DNA occurs more in chromosomes (Nucleus) and less in chloroplasts and Mitochondria
DNA is the genetic material in all organisms except in plant viruses
Hershey and **Chase** showed the genetical nature of DNA by transduction experiments
DNA is referred to as chemical basis of heredity

Structure of DNA:

Double helical model of DNA structure was proposed by **J.D.Watson** and **F.H.C.Crick**
Watson and Crick model of DNA molecule was based on
1) X-ray diffraction (crystallography) by **Franklin** and **Wilkins**
2) **Chargaff's** chemical analysis which showed 1:1 ratios of purines and pyrmidines
3) **Pauling's** proposal of hydrogen bonds between the nitrogen bases
DNA molecule is composed of two strands, spirally coiled with **antiparallel** arrangment
The two strands are closely held by hydrogen bonds
The diameter of DNA molecule is **$20A^0$**, but length is uncertain like a twisted ladder
Each strand of DNA is polynucleotide chain (polymer and nucleotides)
The nitrogen bases of DNA are 4 types namely **adenine** (A), **guanine** (G), **cytosine** (C) and **thymine** (T)
Any nucleotide consists of one of these four types, hence nucleotides are also 4 types based on the type of nitrogen base
Adenine and guanine are called as **purines**, while cytosine and thymine are called **pyrimidines**
Purines are heterocyclic and consist of two C-N rings
Pyrimidines are homocyclic and consists of one C-N rings
In a nucleiotide the sugar and nitrogen base together called as '**Nucleoside**'
Nucleoside with phosphate called as **Nucleotide**
The backbone of polynucleotide strand is formed by alternate arrangement of phosphate and sugar group
The sugar and phosphate groups are linked by **phospodiester bond**
Nitrogen base is attached to the sugar group on lateral side is a nucleotide
The two strands (polymers of nucleotides) of DNA are linked by their nitrogen bases
The bond formation is always between a purine and pyridine, hence they are 1:1 ratio
The nitrogen bases A, T and G, C are complementary to each other
A of a nucleotide in one strand forms hydrogen bonds with T of a nucleotides in opposite strand and vice versa (A = T, T = A)

Properties of DNA:

Molecular weight of DNA is very high (30,000 to several millions)
The absorption spectrum of DNA is high at ultraviolet (260mμ) light
DNA is dentatured when heated upto 70^0C

DNA is dentatured at high pH and low salt conditions
It is the chief genetic material in all organisms **except plant viruses**
Types of DNA :
It was discovered separately by **Rodely** group in NewZealand and **Sashi Sekharan** group in India
In a bacteriophage virus called φx174 phage, the DNA is single stranded
Functions of DNA:
It is the duplication of single DNA into two daughter DNA molecules
During this process two strands of DNA unwind and separate from each other
The two strands separate of the break of hydrogen bonds between complementary strands
The enzyme endonuclease helps in the breakage of hydrogen bonds
The unwinding starts at one end and proceeds to other end
Each separate strand acts as a template and synthesized a new complementary a strand with the help of the enzyme called **DNA polymerase**
The template and complementary strand together form a new daughter DNA, thus two daughter DNA molecules are formed by two templates
RNA (Ribose Nucleic Acid)
It is present more in ribosomes and cytoplasm and little in chloroplasts and mitochondria
It is synthesized in the nucleus with the help of DNA by the enzyme called ‘RNA-Polymerase’ but later released into cytoplasm
RNA is of two types:
1) **Non-genetic RNA** helps in protein synthesis
2) The **genetic RNA** functions as genetic material and found in plant viruses ex: TMV
Structures of RNA:
It is made of single polynucleotide strand
However it is double stranded in **Reo virus** and **wound tumour virus**
The nucleotides of RNA consits of three components namely
1) Phosphate group 2) Ribose sugar ($C_5H_{10}O_5$) 3) Nitrogen base
The nitrogen bases are four types namely **Adenine** (A), **Guanine** (G), **Cytosine** (C) and **Uracil** (U)
Uracil differs from Thymine in lacking a methyl (CH_3) group
Types of non-genetic RNA:
The three types of non-genetic RNA are
1) Messenger RNA (mRNA) 2) Ribosomal RNA (rRNA
3) Transfer RNA (tRNA)
Messenger RNA (mRNA):
It was discovered by Jacob & Monad
It is straight single polynucleotide stranded and occurs in the cytoplasm
The mRNA constitutes 5-10% of total cellular RNA and is higly unstable
Each strand consists of about few hundreds of nucleotides
It is synthesized by DNA template by the process of ‘transcription’ in the nucleus and transported into cytoplasm
Its molecular weight is about 5,00,000
It is ephemeral is prokaryotes and lives for only 2 minutes
It lives for about 4 hours in eukaryotes
It has genetic information for specific protein synthesis
The genetic message or information is present, in the form of triplet codons which are of 64 types
The three nonsense codons are UAA, UAG, UGA
Differences between DNA and RNA:

DNA consists of two strands of nucleotides nucleotides while RNA consists of one strand of nucleotides
Most of the DNA occurs in nucleus while most of RNA occurs in the cytoplasm
Little of DNA present in chloroplast and mitochondria, whereas little of RNA in nucleus, chloroplasts and mitochondria
DNA replicates where as RNA does not replicte
DNA is genetic material where as RNA (mostly) is not genetic material
DNA does not participate directly in protein synthesis where as RNA directly takes part in protein synthesis

Gene Expression & Regulation

1. Gene expression – The process by which a gene (DNA) is made to manifest as a physical & biologically functional gene product, such as protein or RNA.
2. Gene regulation – It gives the cell control over structure & function. It is the basis for cellular differentiation & morphogenesis.
3. Non protein coding genes (r RNA genes, t RNA genes) are not translated into protein.
4. Chromosomal theory explains that chromosomes are the carriers of genes and are the basis for laws of inheritance.
5. Bacterial transformation experiments were conducted by *Griffith*.
6. Transformation experiments were conducted on – *Diplococus pneumoniae* (modern name → *Streptococcus pneumoniae*
7. Two types (or strains) of *Diplococcus* are
   a) R type – Rough, non capsulated, non-virulent form → causing no death.
   b) S type – Smooth, capsulated, virulent form → causing death.
8. Injection of heat killed virulent S form to mice → no harm.
9. Injection of a mixture of heat killed S strain & fresh, live R strain → kills mice.
   (Non virulent R transformed into virulent strains in the presence of heat killed S).
10. Conclusion → Transforming principle might be either the polysaccharide capsule or a compound required for capsule synthesis.
11. Enzymes used in transformation assay tests by Avery & others → protease, amylase, lipase, RNase & DNase.
12. Addition of DNase to S filtrate → no transformation → proved that DNA was the genetic material (a transformation principle or active factor).
13. Confirmation experiment for DNA as genetic material was performed by A.D. Hershey & M. chase by using radioactive isotopes of phosphorus & sulphur on T2 bacteriophage.

<u>Functions of Genes</u>

1. Central dogma of molecular biology – Flow of genetic information from DNA to RNA &, RNA to protein.
2. Gene Expression – The process by which biological information of base sequence of DNA is made available to the cell.

A) Transcription (first step in gene expression) –
   a)Synthesis of m RNA from one of the strands of DNA molecule (in 5' → 3' direction) .
   b) Template – One of the strand of DNA molecule that helps in the synthesis of m RNA.
   c) Non coding or antisense strand – DNA strand that acts as template.
   d) Coding strand or sense strand – Other strand of DNA that do not act as template.
   e) Steps in transcription –
      i) DNA unzips.

ii) RNA polymerase binds to one strand of DNA & it makes an elongating chain of RNA nucleotides (complementary to DNA nucleotide).

iii) Completed m RNA molecule separates (from RNA polymerase–DNA complex) & is ready for translation.

- In Eukaryotes → it moves out from nucleus into cytoplasm.
- In prokaryotes → ribosomes can bind & begin translation before polymerase has completed of new m RNA strand.

B) Translation – a) Synthesis of a polypeptide chain or a protein from m–RNA. It occurs on ribosome.

b) Steps in translation are

i) Ribosome binds to m RNA at a specific area.

ii) Ribosome starts matching t RNA anticodon sequences to m RNA codon sequence that is decoded to respective amino acids, mRNA → transfers its message i.e. genetic code to t RNA.

iii) t RNA searches the amino acid from cytoplasm, carries along with it & adds it to ribosome one by one to form the elongating polypeptide chain.

iv) At a stop sequence, ribosome stops the synthesis, releases polypeptide chain & m RNA.

v) Polypeptide starts acting as a functional protein in the cell.

vi) Amino acids in a polypeptide & nitrogen bases in DNA are <u>colinear.</u>

C) Cistron – A segment of DNA specifying one polypeptide chain in protein synthesis.

D) Muton – The smallest segment of DNA that can undergo mutation (can be as small as one complemental nucleotide pair).

E) Recon – The smallest segment of DNA that undergoes recombination.

3. Genetic code – a) The relationship between the nucleotide sequence of m RNA and amino acid sequence of a polypeptide chain.

b) Codon – A triplet of nucleotides that code for a single amino acid.

c) Anticodon – The triplet of nucleotides in a t RNA molecule, complementary to nucleotide bases of a codon in a m RNA molecule.

d) Initiator codons – i) AUG & GUG (codes for methionine) → initiate translation of m RNA into a polypeptide.

ii) GUG – Initiator codon only in prokaryotes.

e) Terminator codons – UAG (amber), UAA (ochre) & UGA (opal) → terminate the translation.

f) Properties of genetic code –

i) Composed of nucleotide triplets.

ii) Non overlapping – Successive triplets are read in order.

iii) Unambiguous – Each codon specifies only one amino acid.

iv) Degenerate – More than one codon can code for one amino acid.

v) Universal – All organisms use the same genetic code (rare exceptions are in mitochondria & few protozoan species).

vi) Ordered – Multiple codons specifying one amino acid are grouped together.

vii) Commaless – Codons are written in linear form without punctuation.

4. Gene regulation in prokaryotes –

a) Regulated gene – Genes which express their expression whenever the product is required.

b) Unregulated gene – Gene whose expression is encodes a not interrupted. It encodes a products required architecture in the maintenance of basic cellular processes or cell eg. housekeeping gene or constitutive gene.

c) Regulator gene – Genes that regulate the expression of other genes.

d) Operon – A genetic unit that consists of one or more structural genes

& adjacent operator – promoter region to control the transcription.

e) Cis-acting elements – Operator & promoter.

f) Trans-acting elements – Molecules attaching to operator & promoter.

g) Components of Lac operon of E. coli –

i) Structural genes – Three → Z, Y & A.

◆Z gene → synthesises m RNA for an enzyme β–galactosidase (it catalyses the hydrolysis of lactose into glucose & galactose).

◆ Y gene → synthesizes m RNA that translates permease protein (present in bacterial cell membrane that absorbs lactose from external medium).

◆ A gene → synthesizes the enzyme transacetylase (function not clear

◆ If repressor binds to operator, structural genes are switched off.

ii) Operator gene – a) lies upstream next to structural genes.

◆ If it is 'on' structural genes transcribe m RNA.

◆ If it is 'off' structural genes can't function.

◆ It is the target for repressor protein (produced by regulator or inhibitor gene).

iii) Promoter gene – ◆ Actual site of transcription initiation.

◆ Lies upstream next to operator gene

◆RNA polymerase (enzyme catalyzing the m RNA transcription by structural genes) binds first to promoter gene & then move along operator & structural genes.

iv) Inhibitor (repressor) gene & repressor protein –

◆ It synthesizes m RNA for a protein repressor (allosteric molecule).

◆ Repressor binds to operator in the absence of lactose → blocks the path of RNA polymerase → prevents expression of structural genes.

v) Inducer

◆ Molecules that induce the expression of any operon by binding to repressor. eg. Allolactose (isomer of lactose).

◆ It changes the configuration of repressor.

◆ Repressor can not bind to operator .

◆ RNA polymerase pathway is cleared.

◆ Expression of structural genes start.

h) Regulation of Lac operon

i) Permease protein (synthesized from m RNA) present in *E. coli* cell membrane initially takes lactose into cytoplasm by diffusion.

ii) Few molecules of β-galactosidase present in cytoplasm convert lactose into allolactose → an inducer → binds to repressor protein.

iii) Repressor is detached from operator → RNA polymerase pathway is cleared → structural genes synthesize a polycistrionic m RNA.

iv) Large number of β-galactosidase molecules convert lactose into glucose & galactose.

5. Gene Expression in Eukaryotes -

a) Poly A tail is present at 3 end of m RNA.

b) It mediates the transfer of m RNA from nucleus to cytoplasm.

c) Eukaryotic genes are split genes or discontinous genes.

d) Exons –Stretches of bases (regions) in eukaryotic genes that code for amino acids.

e) Introns –Stretches of bases in eukaryotic genes that do not code for amino acids.

f) Split genes synthesize (transcribe) heterogenous nuclear RNA (h n RNA).

g) h n RNA undergoes different steps → 5' capping, intron removal, exon joining & polyadenylation at 3 end → forms m RNA.
h) RNA splicing – Removal of unwanted RNA regions (intron transcripts) & joining of exon transcripts in h n RNA.
i) Spliceosomes – RNA protein complexes that perform RNA splicing.
j) Mostly m RNA is monocistrionic, synthesized from single structural gene.

6. Concept of Gene Action –
a) One -Gene : One-Enzyme Hypothesis –
Beadle & Tatum studied in *Neurospora crassa* & stated that one gene specifies one enzyme.
b) One-Gene : One -Polypeptide Hypothesis –
i) V.M. Ingram et al redefined one-gene, one-enzyme (protein) hypothesis as one-gene, one-polypeptide hypothesis.
ii) eg. Haemoglobin (protein) is a tetramer, containing 4 polypeptides (2α & 2β).
iii) X gene synthesis polypeptides α_1 & α_2.
iv) β gene synthesis polypeptides β_1 & β_2.
v) A mutation in β gene leads to synthesis of sickle cell haemoglobin.
v) Mutation replaces glutamic acid (at 6^{th} position of normal Hb) by valine.
c) Non protein coding genes – t RNA & r RNA are transcribed to synthesize RNA → not translated into proteins.

Objective Bits

166) Chemical basis of heredity is
1) Protoplasm 2) Nucleus 3) Chromosome 4) DNA
167) Chemical analysis of DNA was given by
1) Watson & Crick 2) Wilkins & Franklin 3) Hershey & Chase 4) Chargaff
168) Double helix model of DNA was given by
1) Watson & Crick 2) Wilkins & Franklin
3) Hershey & Chase 4) Chargaff & Pauling
169) False thing with regard to DNA
1) Diameter is 20A0 2) Stands are quite complementary but antiparllel
3) Stands coil around each other clockwisely
4) Strands are held together by H-bonds
170) Rungs in DNA are
1) Sugar-phosphate chains 2) N_2 base pairs
3) Sugar –N_2 base 4) N_2 base and phosphate radicals
171) Sugar –phosphate chains in DNA act as
1) Back bones 2) Steps 3) Axis 4) Polynucleotide strands
172) Purins are
1) Monocyclic and homocyclic 2) Monocyclic and heterocyclic
3) Dicyclic and homocyclic4) Dicyclic and heterocyclic
173) Pyrimidines in DNA are
1) A and G 2) T and C 3) A and T 4) G and C
174) Building blocks of DNA consists of
1) Purins and pyrimidines 2) Sugar – phosphate chains
3) Sugar + N_2 bases 4) Sugar + N_2 base +phosphate
175) Nucleotide differs from nucleoside in

1) Having phosphate 2) Lacking phosphate 3) Lacking N_2 base 4) Having sugar

176) Formula of sugar in DNA is
1) $C_5H_{10}O_5$ 2) $C_6H_{12}O_6$ 3) $C_5H_{10}O_4$ 4) $C_{10}H_{20}O_8$

177) Bond between the following is an ester bond
1) Sugar and Phosphate 2) Sugar and N_2 base
3) Nucleotides of opposite strands 4) N_2 base and phosphate

178) Two strands of DNA are held together by
1) Glycosidic bonds 2) H-bonds 3) Diester bonds 4) All bonds

179) Angle between successive pairs of nucleotides in DNA is
1) $34A^0$ 2) $3.4A^0$ 3) 36^0 4) $36A^0$

180) Number of nucleotides in one coil of DNA
1) 10 2) 20 3) 20pairs 4) 34

181) What is untrue about DNA?
1) Denatures at 70^0C 2) Absorption spectrum is 260nm
3) Denatured at high pH 4) It is the genetic material in all organisms

182) Single stranded DNA is found in
1) α phage 2) T_2 phage 3) ϕ x 174 coli phage 4) Rod virus

183) DNA replicates by ----- method
1) Conservative 2) Semi conservative 3) Non conservative 4) Terminism

184) Semi conservative method of DNA replication was proved to be correct by
1) Watson & Crick 2) Hershey & Chase
3) Messelson & Stahl 4) Temin & Baltimore

185) DNA replication occurs during
1) S-period 2) Metaphase 3) Anaphase 4) Interphase

186) Self replication of DNA is called
1) Heterocatalysis 2) Autocatalysis
3) Terminism 4) Transcription

187) DNA replication is catalysed by
1) Transcriptase 2) Reverse transcrytase
3) DNA polymerase 4) Endocatalysis

188) Formation of mRNA from DNA is
1) Transcription 2) Teminsim 3) Translation 4) Autocatalysis

189) DNA acts as template for the synthesis of
1) Only RNA 2) Only DNA 3) Proteins 4) Both DNA & RNA

190) RNA is mainly concentrated in
1) Nucleus 2) Mitochondria 3) Plastids 4) Ribosomes

191) RNA can act as genetic material in
1) All viruses 2) All plants viruses 3) All animal viruses 4) RNA viruses

192) N_2 base found in RNA and absent in DNA is
1) Adenine 2) Thymine 3) Uracil 4) Cytosine

193) RNA that brings message regarding protein synthesis is
1) rRNA 2) tRNA 3) sRNA 4) mRNA

194) mRNA was discovered by
1) Watson & Crick 2) Ochoa & Nirenberg
3) Jacob & Monad 4) Hershey & Chase

195) In prokaryotes half life period of mRNA is
1) 2 minutes 2) 4 hours 3) Infinity 4) 2 days

196) Genetic message is found in mRNA in the form of
1) Anticodons 2) Replicons 3) Transposans 4) Codons

197) The following is the usual initiating codon
1) AUG 2) GUG3) UAG4) CCA
198) The unstable one is
1) ssDNA 2) dsRNA 3) mRNA 4) tRNA
199) RNA which is almost in the form of a regular double helix
1) rRNA 2) mRNA 3) dsRNA 4) tRNA
200) Smallest nongenetic RNA is
1) mRNAs 2) tRNA 3) Viral RNAS 4) rRNA
201) tRNA constitutes about -----of the total RNA
1) 15% 2) 75-80% 3) 5-10% 4) 2%
202) Clover leaf model of tRNA was proposed by
1) James Boner 2) R.Holley 3) S.Ochoa 4) P.C.Zamecnik
203) Triplet of unpaired nucleotides at 3' end of tRNA
1) AUG 2) GUG3) CCA 4) UAA
204) tRNA identifies genetic message of mRNA by its
1) CCA end 2) Anticodon 3) Extra loop 4) D-loop
205) tRNA cannot be called
1) sRNA 2) Adaptor RNA
3) Interpreter of genetic code 4) Tenaceously bound RNA
206) The following helps in bringing aminoacids into ribosomes during protein synthesis
1) tbRNA 2) tRNA
3) Aminoacyl to tRNA synthetase 4) Peptidyl transferase
207) Kinds of monocyclic N2 bases in nucleic acids are
1) Four 2) Five 3) Three 4) Two
208) Pyrmidine common to DNA and RNA is
1) A 2) T 3) U 4) C
209) Length of DNA is
1) $20A^0$ 2) $34A^0$ 3) Variable 4) Small in all organisms
210) Left handed coiled DNA is
1) Z-DNA 2) B-DNA 3) A-DNA 4) C-DNA
211) The distance between two Nitrogen base pairs of DNA molecule
1) $34A^0$ 2) $6.4A^0$ 3) $4.3A^0$ 4) $3.4A^0$

KEY

161)3	162)1	163)2	164)1	165)1	166)4	167)4	168)1	169)3	170)2
171)1	172)4	173)2	174)4	175)1	176)3	177)1	178)2	179)3	180)2
181)4	182)3	183)2	184)3	185)1	186)2	187)3	188)1	189)4	190)4
191)4	192)3	193)4	194)3	195)1	196)4	197)1	198)3	199)3	200)2
201)1	202)2	203)3	204)2	205)4	206)2	207)3	208)4	209)3	210)1
211)4									

UNIT -XII
BIOTECHNOLOGY

- It is the science of utilising properties cells and cell constituent at industrial level for generating useful products essential for life and human welfare.
- The term biotechnology was given by Carl Ericay Applications of Biotechnology:

1) Production of unique enzymes hormones, vitamins, antibiotics, immuno globin, metabolism from genetically manuplilated or genetically engenereed microorganism
2) Production of alcohol and other fumented products through microorganisms by rapid and Cary method
3) Development of bioscides and biological predatois to encounter diseases and pests on crop plant
4) Non conventional proliferation of commercially important plants through tissue culture
5) Development of transgensi plants & animals which posses specific unique features
6) Production of biogas by fermentation of cow dairy farm refuge, garbage etc by methane bacteria in anaerobic conditions
7) Use of nitrogen fixing micro organisms as biofertilisers to reduce the need of chemical fertiliser
8) Removal of organic matter in seawage by employing diff –types of bacteria, fungi & algae
9) Production of dairy products like curds, cheese, butter using scientific strains of microorganisms

Genetic Engineering: It is a science of deals with synthesis of artificial genes, repair genes, combine genes of different organisms and manipulations of genes for improvement of living organisms

Achievements and Prospects of genetic engineering:

1) It has opened the prospects of introducing genes into bacteria which the prospects of introducing genes into bacteria which will be able to produce fertillisers.It also enables the bacteria to capture energy of sunlight for use as food and fuel and by introducing genes for n_2 fixation into crop plants.
It will increase would food supply.
2) It has introduced a new form of cure system called genetherapy. It can be used for treating heriditary diseases like haemophilie, phenylcutinaria etc
3) It is possible to produce plants and animals with special characters
4) The introduction of gene coding for vitamins antibiotics, harmones from higher animals to bacteria has helped to produce substances which are difficult to synthesise
5) It helps in through study of nature and functions of heriditary material.
Significant information is available about what makes a gene active or inactive

Recombinant DNA technology: It helps to isolate a specific DNA fragment from the genome of an organism which can be insected into foreign organism through vectors and make it express its native characteristics. For example gene responsible for insulin production was isolated from human cell and transferred to bacterium E.Coli. This genetically enginered E.coli produces human insulin. R.DNA technology involves following steps

1) Isolation of gene Genes are isolated by disruption of cells through enzymatic degradation of cell wall and detergent lysis of cell membrane.

a) DNA is extracted from cellular components like proteins and RNA by treating with phenol or suitable nucleases and are subjected to a gradiant centrifugation
b) The purified DNA is cut into a number of fragments by restriction enzymes. Restictions endonucleases were first observed by Nathans. They are a group of enzymes that recoganise

and cut specific nucleotide sequences in DNA known as palindromes. They are 4 –6 base pair in length.

- Different endonucleases recognise different nucliotide sequences and cut DNA at different cleavage sides for example restiction enzymes E.coli recognises GAA and cut it between G &A. When purified linear DNA is treated with different restirction enzymes a large number of DNA fragments are formed. The resultant fragment are seperated from each other by a technique called electrophoresis. The desired fragments are selected by a technique known as Southern blotting.

2) Insertions of gene into Vectors (gene cloning):

- Desired fragments of DNA are insected into suitable vector to produce indefinate number of copies of genes. It is known as gene cloning. There are three major types of vectors. Plasmids, cosmids and bacteriophage.

1) Plasmids: They are genetic material of bacteria. Present in extra chromosomal state & plasmid is defined as a unit of genetic material capable of independent replication in extra chromosomal state

Properties of Plasmids:

1) They are dispensable i.e. they are not required for the survival of the cell in which they recide
2) They are genitive material made up of DNA
3) They are capable of replication
4) They are smaller and seperate from chromosome Plasmids are ideal clonal vectors. Naturally occurring plasmids do not posses all the ideal characteristics of a clonal vector. They should be restrictured by inserting the genes of relaxed replication and genes for antibiotic resistance. On of the standard cloning vectors widely used in gene cloning is PBR_{322}. It is described from E.coli bacteria. It has gene for heristance of two antibiotics tetra cyclin and amphiclin

2) Cosmids: They are plasmids that contain λ phage “Cos” sites and can be packed into phage caprids. They are used to clone large segments of DNA.

(The DNA found in λ phage is doubled stranded with single standed terminal end. These ends are joined when a circle is formed. The double standed region so formed is known as “Cos” site of cohesive site)

3) Bacteriophage: Viruses which attack bacteria are known as bacteriophages. The phage has a linear DNA molecule. A single break will generate two fragments. The two fragments are joined together with a foreign DNA segement. The DNA thus formed is called chimeric DNA. It is allowed to infect bacterium and multiply with in bacterium. The progeny particles are collective after Cytic Cycle

Advantages:

1) DNA can be packed in inuitro into phage particles and transduced into E.coli with high efficiency
2) Foreign DNA of 25 base pair length can be inserted into phage particles
3) Screening and storage of recombinant DNA is easy
4) Introduction of Recombinant Vector in suitable host: The RDNA molecules obtained are then transfered into suitable host cell for expression of gene. The cells into which RDNA molecules are inserted are called transformed cells. The transformed cells are selected with the help of suitable selectable genetic markers.

Genomic DNA library: The single fragment of DNA can be isolated and cloned However it is often preferable to fragment the whole genome and clone all the fragments by using a Vector. But at a later stage the desired clone has to be selected. The complete genome represented in the form of clones is known as genomic DNA library. It contains every DNA sequence in the genome

4) Selections and Screening of desired recombinants: Selection of transformed cells depend upon the nature of gene which is cloned. If it is for antibiotic resistance the cells are first incubated in a medium without antibiotic to allow the plasmid, antibiotic resistant gene to be expressed. Then the cells are placed in a medium with an antibiotic for selection of colonies containing recombinant DNA. A large number of colonies are produced by recombinant clones. It becomes necessary to identify which clone contains the desired gene .One of the most commonly used method is colony hybridisation. It is used to detect the presence of desired genes with the help of probe is a single standard DNA or RNA which is radioactivity labelled. It can search out or Cocate the desired gene

C- DNA: DNA synthesised from mRNA with the help of enzyme reverie transciptase is known as complimentary DNA or LDNA. It is used as problse.

It has several partical application

1) L- DNA can directly be cloned into a vector
2) CDNA probes can be used to detect gene of interest
3) They are used in diagnosis of infectious diseases identification of food contaminant and a variety of microbiological tests
4) Forensic test are conducted with the help of C-DNA probes
5) C-DNA probes can be used to identify different strains of an organisms. Such as varieties of crop sps and microorganisms.

5) Gene transfer: Gene transfer is plants take place by two methods

1) Vector mediated gene transfer: Genes are transferred through natural vectors like viruses, plasmids, transposable genes etc. This method is successful in dicots but not in monocots and direct gene transfer
2) Direct gene transfer: It is carried out by any of the following methods

1) Electro poulation method
2) Calcium mediated ppt atina method
3) Lipozome mediated gene transfer
4) Microinjection of DNA
5) Biolistic method
6) Laser mediated gene transfer:

Transgenic Plants: Genetic engineering can be used to introduce into plants genes which do not exist is any member of same plant family. The foreign or introduced genes are called tramgenes. The plant that contains foreign genes is called transgenic plant

Beneficial Aspects of Transgenic Plants:

1) They are important in increasing in the efficiency of crop plants
2) They are suitable for food processing for example delayed ripening in tomato plants is caused by transgenics
3) Male sterile plants are produced this will eliminate manual emasculation and controll pollination to reduce the cort of hybrid seed production
4) They are used for identifications of regulatory sequences of many genes
5) They can be used as bioreactors for obtaining commercially useful products like medicines, chemicals and antibiotics for large scale production. It is known as molecular fuming.

Applications

1. Controlled or desired use of biological agents (microorganisms or certain cellular components for beneficial purposes) eg. Genetic engineering, polymerase chain reaction.
2. r – DNA (Recombinant DNA) or hybrid DNA or chimeric DNA – DNA located from 2 or more sources combined into a single DNA molecule.

3. Steps followed in r DNA technology –

a) Isolation of Donor DNA desired DNA segment is cut by using restriction endonucleases.

b) Isolation of Vector, a self replicating carrier genetic material – Plasmid vectors are isolated from bacteria by using lysozyme, EDTA & sodium lauryl sarcosinate.

c) Formation of chimeric DNA – Donar DNA & vector DNA are joined by an enzyme ligase.

d) Uptake of DNA – Chimeric DNA is introduced into suitable bacteria.

e) Selection of cells that contain r DNA – Transformed bacteria are identified & selected by using genetic markers or by colony hybridization technique.

f) Transformed bacteria are propagated by culture & product produced from donor DNA is recovered.

4. Enzymes used in r DNA technology -

a) Endonucleases (or restriction endonucleases or restriction enzymes molecular scissors) –Cause a molecule of foreign DNA to break at a particular site – Two types of segments are produced.

i) Blunt ends or flush ends.

ii) sticky ends or cohesive ends.

b) Exonucleases –

c) Ligases – Bind two segments of DNA at the ends.

5. Types of cloning vectors

a) Plasmids – Self replicating extra chromosomal genetic materials in bacteria. eg BR 322.

b) Bacteriophages – i) Small particles or viruses capable of infecting bacterial (can alter the genetic make-up of bacterial cells).

i) Important tools in genetic engineering as cloning vectors. eg. Lambda phage, M13 phage.

c) Cosmids – a) hybrid vectors that include cos gene → form lambda bacteriophage.

ii) Contains drug resistance marker genes & other plasmid genes.

iii) They can incorporate larger DNA fragments or multigene fragments.

d) BAC & YAC – Used as cloning vectors for much longer, DNA fragments to be manipulated.

6. Polymerase chain reaction -

a) A DNA cloning amplification technique

b) used to make a number of copies of a specified gene.

c) 3 successive stages in PCR technique –

i) Denaturation – 2 DNA strands are separated by raising templerature to about 94^0c for one minute.

ii) Renaturation or annealing.

iii) Synthesis or extension – Initiation of DNA synthesis occurs at 3’- hydroxyl end of each primer. Primers are extended by joining bases complementary to DNA strands by DNA polymerase at 72^0c.

7. Industrial uses of microorganisms & r-DNA technology.

a) Microorganisms – Miniature chemical factories.
b) Important microbial products – (i) Immunizing agents or vaccines (ii) Food supplements (iii) Enzymes (iv) Vitamins (v) Antibiotics.
c) 2 major industrial processes of microbial technology – i) Fermentation – Chemical breakdown of a substance by microbes. eg Sugar is converted into alcohol.

ii) Distillation – Process of purifying a liquid by successive evaporation & condensation, collecting the resulting liquid (i.e. spirit).

d) Products manufactured by microbial technology.

i) Alcohols, Acids & vitamins.

- C_2H_5OH → produced by fermentation using yeast (*Saccharomyces cerevisiae*) & bacteria (*Zymomunas mobilis*).
  - Petrochemical ethanol → produced by hydration of C_2H_4.
  - Efficient gasohol (petrol = 80%, C_2H_5OH = 20%) → used as motor fuel in USA.
  - Vinegar (3% to 5% acetic acid) → produced by yeast & bacteria.
  - Citric acid → produced by fungus (*Aspergillus niger*)
  - Lactic acid → produced by bacterium (*Lactobacillus bulgaricus*)
  - Glutamic acid (largest producer among amino acids) → produced by bacterium (*Micrococcus glutamicus*).
  - Vitamin B_2 → produced by *Ashbya gossypii.*
  - Vitamin B_{12} → produced by *Streptomyces olivacens.*

ii) Antibiotics – A substance (drug) that either destroysor inhibits the growth of other microbes e.g, Penicillin, streptomycin, tetracylin etc.

Probiotics – Non pathogenic, beneficial intestinal bacteria. eg. Lactobacilli & Bifidobacteria.

iii) Enzymes –

S.No.	Enzyme	Produced by	Uses
1.	Streptokinase	*Streptococcus pyogenes*	Removes blood vessel's blocks
2.	DNA Polymerase	*Thermus aquaticus*	In PCR technique
3.	Cellulase	*Trichoderma reesi*	Softening & brightening of fabric
4.	Alkaline serene Protease	*Bacillus licheni formis*	Removes protein stains
5.	Rennin	*Mucor pusilu*	Coagulation of milk & cheese preparation

iv) Pollution control –

Bacillus thuringiensis → as biopesticide *Pseudomonas putida* → controls oil pollution. Heterotrophic & autotrophic, bacteria, decomposers (fungi) & ciliate protozoans → treat the sludge.

v) Recombinant vaccines – Provide artificially acquired active immunity.

S.No	Name of vaccine	Description	Used against
1.	Attenuated recombinant vaccines	Live disabled, modified, whole pathogenic organisms	Yellow fever, measles, rubella, mumps
2.	Inactivated recombinant vaccines	Genetically modified whole pathogenic organisms	Hepatitis A, flu, cholera, bubonic plague
3.	Taxoid recombinant vaccines	Exotoxins of microbes	Tetanus, diphtheria, HPV, HBV, TB
4.	Subunit recombinant vaccine or component vaccines	Components of pathogenic organisms (proteins, peptides & DNA)	HPV, HBV, TB
5.	Conjugate recombinant vaccines	Combined with another immunogenic component.	Haemophilus Influenza type B
6.	Vector recombinant vaccines	Vectors genetically modified & employed against pathogens	Vaccinia viruses
7.	DNA vaccines	Plasmid vaccine enters the nucleus of inoculated target cell of host for immunity	Humoral immunity & cellular immunity

vi) Hormones:– insulin → hypoglycemic hormone hGH (somatotropin) → controls metabolism Somatostatin → prevents pancreatitis Erythropoitin → induces erythropoisis.

vii) Interferons – A protein that increase the resistance of a cell to attack by viruses. They are used for treatments of some hepatitis, cancers, dengue fever, rabies & multiple sclerosis.

viii) Monoclonal antibodies (Hybridoma technology) – Normal antibody producing cell (a lymphocyte) fuses with a cell derived from a malignant tumor cell (of lymphoid tissue of a mouse) → hybridoma cell produced (parent cell) → multiplies rapidly → large numbers of monoclonal antibodies produced → used in the diagnosis of antigen, blood groups, production of vaccines that are used in immunoassay, transplantation etc.

Biopiracy

- It is the term used to refer to the use of bio-resources by multinational companies and other organisations without proper authorisation from the countries and people concerned without compensatory payment.
- Most of the industrialised nations are rich financially but poor in biodiversity and traditional knowledge.
- In contrast the developing and the underdeveloped world is rich in biodiversity and traditional knowledge related to bio-resources.
- Traditional knowledge related to bio-resources can be exploited to develop modern applications and can also be used to save time, effort and expenditure during their commercialisation.
- There has been growing realisation of the injustice, inadequate compensation and benefit sharing between developed and developing countries.
- Therefore, some nations are developing laws to prevent such unauthorised exploitation of their bio-resources and traditional knowledge.
- The Indian Parliament has recently cleared the second amendment of the Indian Patents Bill, that takes such issues into consideration, including patent terms emergency provisions and research and development initiative.

Biotechnology

Ex –1

1) Humulin is
   1) An enzyme 2) Gene fragment 3) Antibiotic 4) Rodriguez
2) Restriction enzyme Eco RI cuts the DNA in between
   1) C & G 2) T & C 3) G & A 4) A & T
3) One of the following technique is used to separate DNA fragments
   1) Hybridoma technology 2) Electrophoresis
   3) Gene cloning 4) Molecular farming
4) Small, additional ring of DNA, found along with bacterial chromosome is called
   1) Plasmid 2) Endonuclease 3) Gene4) Palindrome
5) P^{BR-322} is derived from the plasmid of
   1) Bacillus 2) Agrobacterium 3) E.coli 4) Vibrio
6) DNA synthesised from m-RNA with the help of reverse transcriptase is
   1) Cosmids 2) Chimeric DNA
   3) REcombinant DNA 4) Complementary DNA
7) Mostly followed important definition for Biotechnology was given by
   1) American federation of Biotechnology

2) German federation of Biotechnology
3) European federation of Biotechnology
4) Asian federation of Biotechnology

8) The food supplement agent for flavour produced by involving the principles of biotechnology is
1) High fructose corn syrup 2) Monosodium glutamate 3) Rennet 4) Aspartate

9) The bacterium used as biopesticide
1) Lactobacillus 2) Bacillus thuringiensis
3) Rhodospirillum rubrum 4) Chromatium

10) In the process of gene isolation cell membranes are disrupted by using
1) Cellulases 2) Detergents 3) Nucleases 4) Ligases

11) Insulin produced by genetically engineered E.coli is known as
1) Colin 2) Colicin 3) Humulin 4) Rennet

12) The first part of the name restriction enzyme indicates
1) the generic name of the donor 2) the species name of the donor
3) the variety of the donor 4) the character of the donor

13) Descired donor DNA fragments can be identified and isolated by this technique
1) Gel electrophoresis 2) Southern blotting
3) Colony hybridization 4) Immunological technique

14) The method of utilizing transgenic plants as bioreactors for obtaining useful product on large scale is
1) Molecular farming 2) Micro propagation 3) Gene cloning 4) Transgenic

15) Bruise resistant and delayed ripening tomato plants are produced by this method
1) Hybridization 2) Mutation breeding 3) Transgenics 4) DNA finger printing

16) Most commonly used ideal vector for gene cloning
1) Col E1 2) Ecor RI 3) p^{BR-322} 4) Hind 11

17) Enzyme used for cutting donor DNA into fragments
1) Ligase 2) DNase 3) Restriction endonuclease 4) Reverse transcriptase

18) cDNA probes are not useful in
1) Selection of desired donor DNA fragments
2) Selection of transformed host cell
3) Introduction of desired gene into host
4) Diagnosis of infectious diseases such as AIDS

(Single Cell Protein)

19) The 'Torula yeast' that was used in soups and sausages by Germans during II world war is
1) Algubo candida 2) Candida utilis 3) Amanita virosa 4) Lentinus edodes

20) Single celled proteins of algal origin contains
1) Less amount of sulphur containing amino acids
2) More amount of sulphur containing amino acids
3) Less amount of phosphorus containing amino acids
4) More amount of phosphorus containing amino acids

21) Filaments of fungi used in the production of single cell proteins is
1) Fusarium graminearum 2) Chaetomium cellulolyticum
3) Paecilomyces varioti 4) All the above

22) Unicellular yeast used for the production of single celled protein is
1) Candida utilis 2) Candida polytica
3) Saecharomyces cerevisiae 4) All the above

23) The substratum used for the production of single celled protein through

Torula yeasts is
1) Cotton seeds 2) Industrial waste 3) Molasses 4) Paddy straw
24) Baker's yeast is
1) Saccheromyces cerevisiae 2) Candida utilis 3) Candida hipolytica 4) All
25) Neurospora stoplora is a source of
1) Bacterial SCP 2) Fungal SCP 3) Blue green algal SCP 4) Algal SCP
26) Methylophilus methylotropus is
1) Bacterial SCP 2) Fungal SCP 3) Blue green algal SCP 4) Algal SCP

Keys

1)4	2)3	3)2	4)1	5)3
6)4	7)3	8)2	9)2	10)2
11)3	12)1	13)2	14)1	15)3
16)3	17)3	18)3	19)2	20)1
21)4	22)4	23)3	24)1	25)2
26)1				

Ex- 2

1) An immobilised enzyme used in the mass production of high fructose corn syrup is
1) Glucose isomerase 2) Fructose phosphatase
3) Pentose phosphate kinase 4) RUBP
2) Restriction enzymes were discovered by
1) Nathans 2) Buchner 3) Ericay 4) Rodriguez
3) Humulin is
1) An enzyme 2) Gene fragment 3) Antibiotic 4) Human insulin
4) Restriction enzyme Eco RI cuts the DNA in between
1) C and G 2) T and C 3) G and A 4) A and T
5) One of the following technique is used to septate DNA fragments
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3) European federation of Biotechnology
4) Asian federation of Biotechnology
10) The food supplement agent for flavour produced by involving the principles of biotechnology is
1) High fructose corn syrup 2) Monosodium glutamate
3) Rennet 4) Asparate
11) The bacterium used as biopesticide
1) Lactobacillus 2) Bacillus thuringiensis
3) Rhodospirillum rubrum 4) Chromatium

12) In the process of gene isolation cell membranes are disrupted by using
1) Cellulases 2) Detergents 3) Nucleases 4) Ligases
13) Insulin produced by genetically engineered E.coli is known as
1) Colin 2) Colicin 3) Humulin 4) Rennet
14) The first part of the name restriction enzyme indicates
1) the generic name of the donor 2) the species name of the donor
3) the variety of the donor 4) the character of the donor
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1) Gel electrophores 2) Southern blotting
3) Colony hybridization 4) Immunological technique
16) The method of utilizing transgenic plants as bioreactors for obtaining useful product on large scale is
1) Molecular farming 2) Micro propagation
3) Gene cloning 4) Transgenic
17) Bruise resistant and delayed ripening tomato plants are produced by this method
1) Hybridization 2) Mutation breeding
3) Transgenics 4) DNA finger printing
18) Most commonly used ideal vector for gene cloning
1) Col E1 2) EcoRI 3) P^{BR}-232 4) Hind11
19) Enzyme used for cutting donor DNA into fragments
1) Ligase 2) DNase 3) Restriction endonuclease 4) Reverse transcriptase
20) cDNA probes are not useful in
1) Selection of desired donor DNA fragments
2) Selection of transformed host cell
3) Introduction of desired gene into host
4) Diagnosis of infectious diseases such as AIDS
21) All are biopesticides except
1) Bacillus thuringiensis 2) NPV 3) Trichoderma 4) E.coli
22) Widely used and effective vector in plant transgenics is
1) Ti plasmid 2) Cosmid 3) Lysosome 4) P^{BR}-322

Keys

1)1	2)1	3)4	4)3	5)2	6)1
7)3	8)4	9)3	10)2	11)2	12)2
13)3	14)1	15)2	16)1	17)3	18)3
19)3	20)3	21)4	22)1		

UNIT -XIII
PLANTS, MICROBES AND HUMAN WELFARE

- Man depends upon plants directly or indirectly
- Plants are the major source of man's basic needs like food, clothing, fuel, drugs etc.
- Since the beginning of civilization man has been developing new varieties of plants, cultivating them & enjoying their produce
- In order to meet the demand of ever growing population, development of better varieties of crop plants has become a great necessity. Thus the main aim of present day agriculture is to get higher yield by developing superior varieties of crop plants.
- Thus, "The development of new varieties of plants possessing desirable characters from the existing varieties is called Plant breeding.

(or)

Plant breeding / Crop improvement is an applied branch of botany that deals with the improvement of crops & production of new crop varieties which are far superior to the existing varieties in all characters (or) It is an applied branch of botany that deals " with improvement of cultivated varieties of plants".

- Knight – first person to use artificial hybridization to develop new fruit varieties.
- Camerarius – discovered sexual differenciation in plants
- Cotton Mather – identified natural hybridization in plants
- Thomas Fairchild produced first artificial hybrid in maize
- Joseph Koelrenter produced many hybrids in tobacco
- Norman Borlaug – laid foundation of green revolution
  (Architects of Green Revolution)

<u>AIMS & OBJECTIVES OF PLANT BREEDING</u>: Plant breeding aims to improve the characteristics of plants so that they become more desirable. Many desirable characters can be developed in a single variety, so as to make it superior over existing varieties.
Main objectives of plant breeding are ----

- To get higher yield of grains, fibre oil & other plant products.
- To improve the quality of crops with respect to size, shape, colour, taste, nutritional value & storage - ability of the produce.
- To improve high sugar content in sugar crops, high protein content in pulses, long & fine fibers in fibre crops, large size fruits in fruit crops etc.
- To improve varieties which are resistance to drought, frost, diseases, salinity, pesticides & insecticides
- To produce early maturing crops for rotation purpose
- To change the growth habit i.e. to produce dwarf or long varieties, profusely branched or sparsly branched varieties.
- To make harvesting easier
- To induce the adaptability of crop of different climatic & soil conditions

A cultivated variety having majority of the above characters is regarded as "superior variety".
<u>METHODS OF PLANT BREEDING</u>: Methods of plant breeding are dependent upon the type of reproduction & pollination mechanism in plants. Five different methods of plant breeding are ----

- Plant introduction
- Selection
- Hybridization

- Mutation Breeding
- Polyploidy Breeding

I. PLANT INTRODUCTION: It is a process of "introducing high yielding varieties of plants from their natural growing locality into a locality with different climate.

- It is a simple transfer of plants from one place to another
- Portuguese traders in 1510 & East India Company in 1781 introduced many new varieties of plants into Goa & Calcutta Botanical Gardens.
- The newly introduced plant has to adapt or adjust itself to the new or changed environment. This "adjustment of introduced plant into new environment is called Acclimatization".
- "The capacity of plant or group of plants to adapt to changed environmental condition – Acclimatization"
- New plants are usually introduced or imported in the form of seeds or cuttings.
- Great care must be taken while importing a plant material. It carry pathogens & pest along with it.
- Introduced plant material should be thoroughly tested in "Plant quarantine".

MERITS:

- It is the simplest, easiest & quickest method
- No scientific knowledge is necessary
- The new varieties can be directly used in agriculture & horticulture
- Introduced plants serve as a good source of parent material for habridization experiments.
- Introduced plants can be subjected to 'selection' to get better result.

DEMERITS:

- When plants are introduced in a new area, they must show adaptation to changed environment (Acclimatization) otherwise they will perish.
- Plant pathogen & pests may also enter along with the introduced plant material. They may multiply rapidly in the new climate & cause serious damage to the introduced variety.
- Pathogen "Phytophthora infestans" which causes late bright to potato was introduced to India from Europe; Hemileia vastatrix which cause coffee rust was introduced from Ceylon, Urocystes tritics which cause flag smut of wheat was introduced from Australia

ACHIEVEMENT:

- Many disease resistant varieties of different crops are introduced into our country
- Some of the introduced plant varieties are ----

Crop	Variety	Introduced from
Wheat--	Ridley	---------Australia
Wheat---	Sonora – 63	----------USA (Mexico)
	Sonora – 64	--------- USA (Mexico)
Sweet Potato	F.A – 17	---------China
Rice ---	IR – 8	---------Philippines
	TN – 1	---------Taiwan
Maize	Dixie –11, 22	---------USA
	Texas – 21	---------America
Tomato	Sioux Var	--------America

II. SELECTION:

- It is the oldest method of breeding. It is the basis for all crop improvement method.
- It may be defined as the "Process of selection of individual plant or group of plants which shows desirable superior characters".
- Selection is of two types i) Natural selection ii) Artificial Selection

i) NATURAL SELECTION: It is the natural process

- Natural selection is based on "Survival of fittest"
- According to Darwin's principle 'Survival of fittest' plants which survive through the adversities of nature are preferred & the weak ones are wiped out. Thus nature itself selects the fittest organism.
- Regional varieties which are adapted to local climatic conditions are known as ecotypes
- Different ecotypes & cultivated plants are formed only because of natural selection.
- Ecotypes provide the basis for artificial selection & hybridization.
- Selection pressure ultimately resulted in the appearance of many differences between species & sub – species

ii) ARTIFICIAL SELECTION: It is defined as "Selection of plants with desirable characters & superior gene combination from mixed population artificially by man".

- Man is the major agent which influences the plant selection continuously under domestication.
- Many domesticated animals & cultivated plants have developed from wilder ancestors by selection.
- Selection & mutation are powerful tools in the hand of breeders to change the characters of plants & animals to his advantage.
- These are three methods of artificial selection -----

i) Mass selection ii) Pure line selection iii) Clonal selection

MASS SELECTION: It is the simplest & oldest method

- It is the method of selection in which "Plants with desirable characters are selected on the basis of phenotype from a mixed population.
- It is practiced in cross pollinated crops
- In mass selection plants showing desirable characters like vigour, yield, resistance to pest, diseases etc are selected.
- The seeds of these plants are collected & are used to raise the crop in next year.
- The same process is repeated for 8 – 10 generations. Finally they are multiplied & distributed to the farmers for cultivation.
- In mass selection, the desirable qualities of a selected variety gradually decreases which is due to increase in heterozygosity

MERITS:

- It is easiest & quickest method
- It needs no scientific knowledge
- Pollination need not be controlled to produce new variety
- It is the only method of improving wild or local varieties of cross-pollination crops.

DEMERITS:

- Importance is given only to the phenotypic characters
- It is applicable to only cross pollinated crops
- These is no control over pollination & hence heterozygosity increases & the desirable qualities diminish
- Importance is given to female parent. Genotype of male parent is not considered.

ACHIVEMENT:

Cotton: Dharwar American, Dodahatti local, Cambodias etc.
Ground nut: TMV –1, TMV –2, AK – 10, K –122 etc
Bajra: Pusa Moti

PURE LINE SELECTION:

- Pure line selection method proposed by Johannsen of Denmark in 1903 by his experiment on 'Princess' variety of beans (Phaseolus vulgaris)
- The progeny of a single self pollinated, homozygous plant is known as "Pure line" – Sinnot etal.
- The method of production of variety from the pure line is known as "pure line selection".
- It may also be defined as 'The process of isolating a desirable homozygous individual from the mixed population & multiplying the same without contamination to release as new variety'.
- Pure line selection is applicable to self-pollinated crops. Ex: Rice, Cotton
- Progeny of pure line is similar in phenotype & genotype
- Procedure: 100 – 200 plants are selected from the mixed popution. Seeds are collected separately.
- The seeds are grown in separate lines. Plants with desirable characters are selected & seeds are collected.
- The same process is repeated for about 8 –10 generations until a new variety is isolated.

MERITS:

- This is the only method to improve the local varieties of self-pollinated crops.
- New plant variety is uniform in genotype & phenotype
- The method is also useful for the production of pure line & inbred line in cross-pollinated crops.

DEMERITS:

- It is very lengthy & laborious process.
- New characters / new genotypes can not be introduced into a plant variety
- It is not possible to improve a variety beyond a certain level of homozygosity
- Extreme homozygosity may results in low yield & other undersirable characters.

ACHIVEMENTS: A large number of new varieties have been developed by this method ----

Wheat: NP –4, NP –6, K –13, K –15 etc
Rice: Co –4, Co –6, Co –10, Mtu –3 etc
Cotton: Co –2, RC –50, Gourani, Nandyala –14, Coconda –1 etc
Groundnut: TMV –3, Kt varieties
Tobacco: NP –28, T –59 etc
Castor: HC –1, HC – 6

CLONAL SELECTION:

- Progeny of a single plant obtained by vegetative propagation is known as 'Clone'
- The method of developing varieties from the clones is known as clonal selection.
- It is a method of improving vegetatively propagated crops
- All the plants of a clone are simular in phenotype & genotype
- Many vegetative parts such as setts, cuttings, tubers, suckers etc are the units of clonal selection.
- Healthy units from healthy plants are selected on the basis ofdesirable phenotypic characters
- Diseased & poor yielding clones are discarded
- Selection within the clone is never effective unless mutations intervens, as all the individuals within a clone have same genenotypic constitution
- Selected clones (may be any part of the plant body) are multiplied by a particular method of vegetative propagation & are then compared with normal variety
- The best performs are selected & carried on trials at different regional stations for 3 years.
- The best ones are multiplied & distributed to the farmers.

ADVANTAGES:
- Varieties developed by clonal selection are stable as segregation of characters does not occur.
- Variation do not takes place in the genotype
- Mutations can change the characters
- Hybrid vigour can be preserved for several generations
- It is applied for improving vegetatively propagated crops

DISADVANTAGES:
- It is not applicable to sexually reproducing plants
- It is utilized to isolate superior genotype from mixed population
- Plants with new genotypes can not be produced

ACHIVEMENTS: Some vegetatively propagated crops improved by clonal selection are ----
Potato: Kufri Red, Kufri safed
Mango: Mudapa Pedda Neelam
Banana: Bombay Green, High gate, Peda Monthan

III. HYBRIDIZATION: It is the most important method of plant breeding
- "The crossing between two plants with different genotypes is known as Hybridization".
- Hybridization results in genetic recombination & production of new varities of plants
- German botanist Joseph Kolreuter (1760 –66) was first to utilize hybridization to improve plants
- Many desirable characters from various varities can be incorporated into a single variety.
- Hybridization is practiced in self & cross pollinated crops
- Based on taxonomic relationships of the two parents, hybridization is of 3 types

i) Varietal Hybridization ii) Interspecific Hybridization
iii) Intergeneric Hybridization

i) VARIETAL HYBRIDIZATION: "Hybridization carried out between two plants of the same variety or between two varieties of the same species".
It is of two types ---- Intravarietal Hybridization
Intervarietal Hybridization

Intravarietal Hybridization:It is carried out "between two different plants of the same variety".
- It is helpful in improving self pollinated selected
- Two plants with different genotypes are selected to produce new plant with desirable characters

Intervarietal Hybridization: It is carried out "between two different varieties of same species".
It is also known as intraspecific hybridization
- It is utilized in the production of superior varieties in self pollinated crops
- Ex: (a) A new variety of rice 'Jaya' was produced by crossing TN –1 variety with T-141 with TN-1
(b) 'Pusa Rubi' variety of tomato was produced by crossing Sioux with meruti

ii) INTERSPECIFIC HYBRIDIZATION: (Intrageneric hybridization) It is carried out between "two different species of the same genus".
- It is utilized to transfer one or two good/desirable characters from wild species to cultivated species
- Characters like resistance to drought are present in wild species. These characters can be transferred to cultivated species
- Ex: (a) Resistance to tobacco mosaic virus is present in N.glustinosa, which can be transferred to N.tobaccum.

(b) Wheat: Triticum aestivum x T.durum $\rightarrow$P.1.9485
(resistant to Hessian fly)
Cotton: G.hirsutum x G.arborecim $\rightarrow$Deviraj variety
(c) Tomato: L.esculentum x L.pimpinellifolium $\rightarrow$Red pulm variety

III. INTERGENERIC HYBRIDIZATION: Hybridization that is "carried out between the two genera of the same family".

- Russian genetiest Karpechenko made a cross between R.sativus (radish) & B.oleracea Variety capitata (cabbage) & synthesized a new genus Raphanobrassica (rabbage – a tetra ploid)
- Muntzing (1979) made a cross between T.aestivum (wheat) & Secale cereale (rye) & snthesized new genus 'Triticale'.

HYBRIDIZATION PROCEDURE: It involves different steps

Ist Step---SELECTION OF PARENTS:

- Plants having desirable characters like height, vigour, resistance to disease, pest, yield etc are selected as parents.
- Plants are selected from local collections as they are well adapted to local environmental conditions

2nd SELFING OF PARENTS:

- The plants selected as parents are self-pollinated so as to decrease heterozygosity.
- Desirable characters are present in homozygous condition
- The process of producing genetically similar progeny from cross-pollinated plant by self-pollination $\rightarrow$ "Inbreeding" The progeny is called "Inbred line".

EMASCULATION: may be defined as ----

- "Removal of stamens from flower of female parent".
- It prevents self-pollination in female parent.
- Emasculation is done by removal of stamens with the forcep or by immercing the inflorescence in hot water (40 – 50^{0}C) for 1 –10 minutes.

BAGGING:

- Immediately after emasculation, flower/inflorescence of the female parent is covered with butter paper or polythene bag.
- Bagging prevents undesirable cross pollination
- Bag is punctured to provide ventilation & to prevent the development of fungus
- Bag is labelled showing the data is tagged on it

ARTIFICIAL CROSS POLLINATION:

- Emasculated flowers are artificially cross-pollinated by collecting the pollen grains from male parent.
- After artificial cross-pollination the female flowers are bagged again to prevent unwanted cross-pollination.

HARVESTING OF HYBRID & RAISING F_1 PROGENY:

- Cross pollinated flowers are harvested & seeds are used to raise F_1 generation
- F_1 plants are heterozygous with uniform phenotype & genotype.

HYBRIDIZATION METHODS:

- F_1 plants are selfed, seeds are collected & are used to raise F_2 progeny
- F_2 plants with desirable characters are selected & are improved by selection methods

TRIAL, MULTIPLICATION, DISTRIBUTION:

- Hybrid variety produced by selection method is subjected to rigorous testing at different localities
- If the variety is found stable seeds are multiplied & distributed to cultivators

MERITS:

- It results new genotypes & varations
- It brings many superior characters in single variety
- It results in the production of more vigorous & better adapted varieties

DEMERITS:

- It can be handled by experienced plant breeders.
- It is time consuming & laborious process
- It results in the production of sterile hybrids in some plants

ACHIVEMENTS:

- Rice: Deccan –101, Jaya, Sabarmati, Padma, Krishna etc
- Wheat: NP –165, NP –710 etc
- Maize: Ganga –3, Ganga –7, Ganga safed etc
- Cotton: MCU, Lakshmi etc
- Tomato: Pusa Red, Pusa Ruby etc

HYBRID VIGOUR / HETERDSIS:

- The progeny obtained from hybridization is called as hybrid plants.
- The hybrid plants are generally more vigrous / superior than their parents
- Hybrids are superior over the parents in characters like height, yield, resistance, size of fruits & grains etc.
- "The superiority of hybrid over its parents in sizes growth, yield, vigour etc is known as heterosis"
- Hybrid vigour was first noticed in hybrids in 18^{th} & 19^{th} centuries by Koelreuter
- The term Heterosis was introduced by G.H shull (1914). He subjected maize plants to self-pollination for several generations. In the progeny these was a decrease in vigour, yield etc. This progeny is called as inbred lined & the process is called as "inbred depression". He crossed two inbred lines (weak progeny) & observed that the resultant hybrid shows heterosis. The vigour lost in parents is regained. Shull named this vigour of hybrid over the parent as heterosis.

  Inbred depression: loss of vigour, yield etc due to self-pollination for several generations

Production & Utilization of Hybrid Vigour: It involves different steps

- The 1^{st} step in to produce homozygous inbred lines

  Ex: Production of inbred lines A, B, C, D

  Inbred lines are produced by subjecting cross-pollinated plants to self-pollination upto 5 – 7 generations
- The second step in the crossing of two different inbred lines. This crossing is called as single cross. For ex: The cross between A & B , A&C , B&C, B&D, A&D etc
- The single cross hybrids are uniform & productive.
- If the single cross hybrids shows desirable characters it is released as new variety
- Hybrid vigour in these plants is not retained in next generation
- The 3^{rd} step in the crossing of two single crosses which is known as double cross. For ex: cross between (AxB) & (CxD); (AxC) & (BxD); (AxC) & (CxD); (AxD) & (BxC) etc
- In double cross, 4 inbred lines are involved
- Double cross hybrids are more vigorous
- Hybrid vigour in double cross plants is retained for several generations

  Ex: Sorghum, Maize, Cotton, Bajra etc

MUTATION BREEDING:

- Mutations are the sudden heritable changes in the genotype of the organism
- It is discovered by Hugo de Vries in Oenothera lamarckiana
- He coined the term mutation
- Mutation occurs due to change in the structure of gene (Gene Mutation) or Chromosome (Chromosomal Mutation)
- Mutation that occurs in somatic cells- somatic mutation
- Mutations which occurs automatically in organisms is known as Spontaneous Mutations
- Mutations which are produced artificially in organism are known as induced mutations
- The agents which induces mutations are called mutagenic agents / mutagens
- Mutagens may be physical or chemical agents
- Examples of physical mutagens – X rays, gamma rays, beta rays, neutrons, UV radiations etc
- Examples of chemical mutagens – mustard gas, nitrous acid, colchicines, hydroxyl amine, ethyle methane sulphonate etc
- H.J.Muller (1927) induced mutations in Drosphila for the first time by using X- rays
- Induced mutations may be utilized for crop improvement by changing their genotype
- The utilization of induced mutation for the improvement of crop is known as “mutation breeding”

MERITS:

- Mutations create new variations among organisms
- Mutations are useful in improving specific characters of a well adapted high yielding variety

DEMERIT:

- Mutations are generally recessive
- Mutations cannot be detected easily
- Desirable mutations associated with undesirable characters. To remove undesirable characters, mutant should be back crossed with the present. This back crossing involves additional time, labour & expensces.
- To select desirable mutants, plant breeders has to screen large population

ACHIVEMENTS:

- Rice – Jagannath
- Wheat –NP – 836, Sharbti Sonora
- Cotton – Indore –2, MCV – 7
- Tomato – Pusa Lal meerut
- Castor – Aruna Variety

POLYPLOID BREEDING:

- Most of the plants are diploid & contains two sets of chromosomes
- Some plants contain more than two sets of chromosomes such plants are called as “Polyploids”.
- Polyploids are larger in size
- Polyploids are superior over diploids & hence are utilized for crop improvement
- “The production & utilization of polyploids for improvement of crops is known as polyploid breeding”.
- Triploids, tetraploids & hexaploids are the examples of polyploids

(a) TRIPLOIDS: “Organisms with 3 sets of chromosomes”.

- Cross between diploid & tetraploids produce triploid variety. They are generally sterile.
- Seedless watermelons (Citrulla vulgaris) is produced by crossing tetraploid female plant with diploid male plant
- Triploid variety TV – 29 of tea produces larger shoots, leaves & is more tolerant to drought
- Commercial Banana (M.Paradisica) is triploid & has larger & seedless fruits

<u>TETRAPLOIDS</u>: "Organisms with 4 sets of chromosomes" They are of two types ----

(i) <u>AUTOTETRAPLOIDS</u>: are the organisms with "similar set of chromosomes".

- They are produced by doubling the number of chromosomes in diploids
- Autotetraploids have larger leaves, flowers, fruits & seeds compared to diploids, hence they are produced artificially& used in agriculture
- Autoploidy can be induced by high & low temperatures acenaphthene, colchicine, Coumarin etc
- Colchincine inhibits the formation of spindle apparatus & hence cytokinesis does not occurs. The chromosome number of treated cells gets doubled
- Ex: Pussa giant berseem (Trifolium alexandrium) in the first polyploid variety released for general cultivation. It yields 20 – 30% more grass fodder than diploid variety
- Sugandha is another autotetraploid of Vetivar grass that gives 10% more oil yield than diploids

ii) <u>ALLOTETRAPLOIDS</u>: are the organisms with "dissimilar set of chromosomes".

- They are produced by crossing distantly related species or genera of the same family
- Chromosome complement of F, hybrid is doubled artificially
- Plants produced by this method are sterile
- They are made fertile by doubling chromosome number by Colchicine
- They are also called as 'amphidiploids' as they contain two diploid sets of chromosomes of two different species
- Some examples are -----

White cotton ---- G.hirsutum x G.barbadense
Tobacco ----- N. tobaccum x N.rustica
Raphanobrassica ----- Raphanus x Brassica

$$\begin{array}{cc} 2n = 18 & 2n = 18 \\ n = 9 & n = 9 \end{array}$$
$$\downarrow$$
F_1 hybrid $\rightarrow$Raphanobrassica
9R+9B 18R+18B (4n = 36)

- Chromosome number is doubled by using Colchicine
- Raphanobrassica is the first synthetic genus
- Experiments of Barpechenko (1927) helped in the production of this alloploid
- Triticale is developed by polyploid breeding

<u>HEXAPLOIDS</u>: organisms with "6 sets of Chromosomes"

- Commercial bread wheat i.e. Triticum aestivum is an example of allohexaploid

Triticum monococcum 2n = 14 AA	x	Aegilops spettoides 2n = 14 BB

$$\downarrow$$

AB (hybrid)
2n = 14

(Sterile)

↓ doubling

4n = 28
AA BB
(Amphidiploid)

x

Aegilops squarrosa
2n = 14
DD

↓

Triploid hybrid
3n = 21
ABD (Sterile)

↓ doubling

Triticum aestivum
6n = 42
AA BB DD
Hexaploid wheat

- Presence of multiple sets of chromosomes representing autopolyploid & allophyploids is known as "enploidy"
- Variation in the chromosome no with in the genone is known as "anenploidy"

Limitations:

- Any increase in chromosome number in the already existing natural polyploids, the size of leaves, flowers fruits etc can also reduces

In polyploids, vegetative growth is more & seed fertility is less. Hence it is widely used in fodder & forage crops & plants where roots & tubers are useful parts.

TISSUE CULTURE

- Flowing plants normally propagate through vegegetative method or seeds which germinate to produce new plants → " in vivo"
- New plants can also be produce in the laboratory by culturing the cells, tissues or organs. This technique is called as " in vitro" culture/ technique/ tissue culture
- The genetic complement of any cell in the diploid organism is similar to that of zygote. Therefore each cell has an inherent capacity to develop into a complete plant by regeneration when proper external conditions are provided
- This inherent potency of the cell to grow into a complete plant under controlled conditions is called as "CELLULAR TOTIPOTENCY". This property is found only in plants
- The term totipotency is coined by Morgan (1901)
- The idea of cellular totipotency was expressed by Schwann (1839)
- Growing the cells, tissues or organs on the artificial medium is called as "Tissue culture" or "Organs culture"
- The idea of tissue culture was given by Haberlandt

ASPECTS OF TISSUE CULLTURE:

- Important aspects of tissue culture are ----
  i) Nutrient medium ii) Aseptic conditions iii) Aeration

i) NUTRIENT MEDIUM:

- Cultured tissues or organs can not synthesise their own food material. They require nutrients for their normal growth.
- Nutrients must be supplied through the medium

- Medium containing sucrose, mineral salts & vitamins is known as “minimal” or “basal” medium
- The medium must also contain growth regulators like auxins, cytokinins in different proportions to intiate organogenesis. Such medium is called as “complete medium”
- Natural plant extracts such as coconut milk, fruit juices, yeast extract etc contains vitamins, harmones etc, hence can be added to minimal medium
- Various components of the medium should be dissolved in distilled water
- The medium can be made semi- solid by adding Agar – Agar (0.8%) to the medium. The p^H of the medium should be 5.8

ii) ASEPTIC CONDITIONS:

- Sugary nutrient medium is best for microbial growth which may check the growth of plant tissue or may even kill the tissue. Therefore medium must be made free from microbes i.e. should be made aseptic
- Aseptic conditions can be achieved by ---
    (a) Micro organisms may be present in the medium itself. The medium must be sterilized with the help of an auto dave by heating upto 120^0C under 15 lbs. pressure for 15 – 30 minutes
    (b) Entry of microbes can be prevented by plugging container with sterilized cotton
    (c) Entry of microbes along with the tissue can be prevented by disinfection of the tissue with chlorine water or alcohol
    (d) Inoculation chamber must be sterilized

iii) AERATION:

- Plants tissue require continuous supply of oxygen.
- If tissues / organs are cultured on solid medium atmospheric O_2 is available to them
- If they are cultured in liquid medium. They are immersed in liquid medium & O_2 is not available to tissue or organs. Aeration can be provided by passing filter – sterilized air & shaking the medium
- Aeration (in liquid medium) can also be provided by arranging filter paper bridge & tissue is kept over it, in contact with the medium
- Aeration can be provided by making the medium semisolid with the addition of agar –agar & keeping the tissue on the surface of the semisolid medium

TISSUE CULTURE TECHNIQUE:

- Suitable medium should be prepared first
- A small piece of tissue is removed from any suitable part of the plant
- The tissue should be disinfected & placed over medium.
- The cells divides & redivides to form undifferenciated mass of cells known as “Callus”
- Differentiation of organs from callus is known as morphogenesis or organogenesis
- Morophogenesis can be induced by growth regulators
- Addition of auxin (NAA) induces formation of roots
- Addition of cytokinins (kinetin) initiates stem /shoots
- Non- zygotic embryos formed in culture are called as embryoids
- Embryoids develops into plantlets which are highly delicate as they are grown in atmosphere containing 100% humidity
- Cuticle is absent in the stem & leaves of plant lets
- The plantlets are grown in excessively humid areas later humidity is slowly reduced.
- They can grow in normal atmosphere after 4 –6 weeks & are ready for transplantation

TYPES OF ORGAN CULTURE:

- Culturing of organs on artificial media is “organ culture”

- Depending upon the organ, organculture is of different types. They are ---- antherculture, embryoculture ovuleculture, ovaryculture etc.

ANTHER CULTURE:

- Culturing of anthers is known as 'anther culture'
- The plantlets developed from single pollen grains are haploid sporophytes (sterile)
- Anther culture was first carried out by Shimakura (1934) in Datura to study the physiology of meiosis
- Guha & Maheshwari (1964) also cultured anthers of D.innoxia & observed the development of embryoids, on culture medium containing kinetin, coconut milk or grape juice
- Embryoids develops into new plant lets
- The basic principal in such culture is the production of haploid plantlets which is based on totipotency
- Development of haploid plants in 'vitro' from totipotent pollen is called as 'androgenesis'

Technique of Anther culture:

- A suitable culture medium containing 2% sucrose, coconut milk, minerals & growth regulators is prepared
- Mature anther are selected & excised (separated or removed) from the flower bud. They are sterilized & transferred to nutrient medium at 25 – 28^{0}C
- Ex: Nicotiana tobaccum produce 58% embryoids at 5^{0}C for 72 hours, 21% embryoids at 22^{0}C for 72 hours
- Uninucleate pollen grains are more suitable for culturing
- Microspores / pollen grains divide repeatedly to form multicellular body
- This tissue form callus later develops into embryoids
- Embryoids upon isolation develop into plantlets
- When callus is formed from several pollen grains, plantlets formed from such callus shows Chimara condition

  To overcome this problem isolated pollen grains are cultured to produce haploid sporophytes

USES/ APPLICATIONS OF ANTHER CULTURE:

- Haploids are used to produce new genotype which are doubled to form fertile homozygous diploids
- Recessive mutations can be detected easily
- They serve as good material for physiological & biochemical studies
- They are used in genetic engineering. For ex: haploid tissue of tomato is used to transfer express genes from E.coli
- The production of haploid plants shortens the breeding period & recovers several gene combinations

IMPORTANCE OF HAPLOIDS IN HIGHER PLANTS:

- It is difficult to detect recessive mutations in diploid plants
- Haploid tissue belonging to diploid plants can be obtained from haploid plants
- Haploid plants are utilized to produce homozygous diploid plants. The homozygous diploid plants are used in plant breeding & genetical research

EMBRYO CULTURE:

- "The culture of embryos of different developmental stages on nutrient medium is known as Embryo culture".
- Hanning (1904) was the first to grow embryos of Brassicaceae members

  Ex: Raphanus sps

- In embryo culture, embryos are isolated under aseptic conditions & are transferred on suitable nutrient medium
- The immature embyos grow well on medium which is rich in vitamins, growth regulators & amino acids
- Mature embryos grow well on basal medium
- Embryos develop into plants in 4 –5 weeks

APPLICATIONS OF EMBRYO CULTURE:

- In some plants, embryo develop upto certain stage & aborted. Such embryos are cultured on nutrient medium to produce plants. This is called as embryo rescue.
- The seeds of several ornamental plants & fruits bearing trees remains dormant for a long period. The embryos of such seeds can be grown 'in vitro'
- Fertility of the seed is tested by breaking the dormancy & by promoting germination
- Hybridization between plants of distantly related genera or between incompatible parents produce weak embryos, which can be recued & cultured 'in vitro' to produce rare hybrids

APPLICATION OF TISSUE & ORGAN CULTURE:

Some important applications of tissue culture are -----

- It is possible to produce a large number of plants with in a short time & space through tissue culture
- Mass propagation of plants through tissue culture is known as microporpagation Ex: Ornamental plants (orchids), fruits yielding plants etc can be propagated by this technique
- Dormancy period can be reduced & fertility of the seed can be tested quickly
- Rare plants can be propagated
- Embryos of hybrids having more hybrid vigour & disease resistance are naturally abortive. Plats can be produced from such embryos by this method
- Storage of plants in the form of tissue is easier
- Vegetative propagation is essential in dioecious plants

  Ex: In Carica papaya, only female plants are important. A few male plants are required to produce pollen grains. It is difficult to identify the plants before flowering. To avoid this female plants are cultured
- Viral diseases from plants can be prevented by producing virus free plants from shoot tip culture.
- Somatic hybrids can be produced by culturing hybrid protoplast 'in vitro'
- Haploids are produced through antherculture & fertile homozygous diploid plants are produced from them by doubling the chromosomes with colchicines
- Tissue culture of medicinal plants helps in production of high value products of industrial & medicinal importance
- Production of transgenic plants by the transfer of foreign genes is completely dependent upon tissue culture
- Storage & preservation of germplasm through "cold – storage" procedure of plants as well as plant parts called as cryopreservation

SINGLE CELL PROTEIN (S C P)

*Plant & Humanwelfare***:**

- Cells of microorganisms grown for proteins are called single cell protein. They are useful as food for humans and as feed for animals
- Single celled confilamentous microorganisms are used as protein producers. These proteins are called proteins (S C P)
- These dried cells contain protein of single species hence it is called single cell protein

- SCP microorganisms – Alagae (Spirulina maxima)
  Fungi (Aspergillus)
  Yeast (Candida utilis)
  Bacteria (Bacillus)
  Actinomycetes (Norcardia)
- In ancient times filaments blue green alga spirulina was harvested from the lake clad in Africa and used as food for man
- During I[st] world war Germans used Candida utilis (Torula yeast in soups and sausages)
- Raw materials — Suitable scp organisms
  Hydrocarbons — Bacteria, yeast
  Agricultural wastes — Filamentous Fungi
- Estimated need of protein in developing countries by 2005 is about 25 million tons
- Advantages of scp producing microorganisms
  i) High protein, low fat content
  ii) Aood source of vitamins, especially B complex is yeast and mushrooms
- Unlike crops they can be produced throughout the year
- SCP microorganisms grow on waste material and effluents thus help in reducing pollution and recycling of material
- They are fast growing, and they need small area and limited value
- They contain desirable amino acids and can be selected (or) produced by genetic engineering
- They also produce useful byproducts like organic acids, fats, oils etc
- *Nutrients values of SCP*:
  Protein : 74%
  Methionine : 2.3%
  Cystein : 2.3%
  Lysine : 4.6%
  Calcium : 0.07%
  Phosphorous: 2.4%
  Energy : 13.4%
- Vitamins available from SCP:
  B_2 : Riboflavin
  B_{12} : Cobalamine
  Ascorbic acid : Vit C
  Calciferol : D_3

Source of SCP:

- Algae, fungi and bacteria are used as SCP, some important features of these organisms are

S.No.	Organism	Substrate used for SCP production	Used as	Protein content %
1.	Algae			
	a) Chlorella sp		Feed	Upto 60%
	b) Scenedesmus acutus	CO_2 + sunlight	Food 7feed	
	c) Spirulina maxima			
2.	Yeast			
	a) Candida utilis	Ethanol	Food	55 – 60%
	b) Saceharomyces Cerevisiae	Molasses	Food	
3.	Fungi			
	a) Chaetomium Celluolytium			
	b) Fusarium graminearum			
	c) Paecilomyces			

Algae:
- In algae, chlorella, scenedesmus and spirucina are grown to harvest SCP. It contains about 60% protein which contains good amino acid composition with less sulphur containing amino acid
- It is suitable for animal feed but not suitable for human consumption as it contains chlorophyll
- Chlorella and Spirulina are used to produce SCP on large scale in Japan, Taiwan, Mexico, Israel, Thailand, USA
- In India they are grown an waste water in Lucknow

DISADVANTAGES:
- Algae are rich in chlorophyll and not suitable for human consumption
- Low density i.e. 1-2g dry Wt /L of substrate
- Severe risk of contamination during its growth

Yeast and Fungi:
- Filaments fungi used for SCP are Chaetomium Cellulolyticum, Fusasrium graminearum and paecilomyces varioti
- Unicellular yeasts used for SCP are Candida utilis, C.Lipolytica and Saccharomyces cerevisiae
- Torula yeast a source of SCP with 5 high protein content is obtained through fermentation by using molasses as a substrate
- It is rich in Lysine which is very essential amino acid in feed
- And it is deficient in amino acids like Methionine and Cysteine
- Yeast used for SCP belongs to Saccharomyces cerevisiae (Baker's Yeast) which is highly suitable as poultry feed
- SCP of yeast is obtained as a byproduct of molasses (or) sugarcane juice fermentation
- Raw material used for other SCP fungi like Rhizophus SPP and Neurospora Stoploea is peanut preees cake coconut press cake, Soybean hypocotyledous

Disadvantages of Fungal SCP:
- High Nucleic acid content
- Slower growth rate than yeast and bacteria

- Risk of contamination
- Some may produce mycotoxins hence strains should be screened

Bacteria:

- Methlophilus methylotrophus is grown on Methanol
- Bacterial SCP is rich in protein and amino but deficient in sulphur containing amino acids
- Nucleic acid content is high

Disadvantages of SCP:

- High RNA content
- High risk of contamination during production
- Careful testing for endotoxin production is essential

Bee-Keeping(APICULTURE)

1. Rearing of honey bees is called **Apiculture** and
2. 3 species of honey bees found in India
   a) *Apis indica* – Domesticated.
   b) *Apis dorsata* or wild rock bee – Largest
   c) *Apis florae* – Smallest
3. Three casts in a bee colony are: a) Queens b) Drones c) Workers
4. Bee hive:
   a) It contains a vertical comb with horizontal hexagonal cells made by bee wax, secreted by wax glands of worker bees.
   b) It contains two types of cells
      i) Storage cells – Upper cells, used to store honey & pollen.
      ii) Brood cells – Worker brood cells – upper, drone brood cells–middle, queen brood cells–lower most ground net shaped.
5. Total number of bees in a colony is about 50,000.
6. Development is holometabolous
7. Larvae are grubs.

8. Queen

   a) One in each hive, diploid.
   b) Large with reduced wings
   c) Large abdomen containing ovaries to lay eggs. (2000 eggs per day & 1 million in life time)
   d) Virgin queen copulates with male during nuptial flight, receives 90 million sperms & stores in her spermathecae to fertilize the ova for rest of her life.
   e) Fertilized eggs develop into females
   f) Unfertilized eggs develop into males called drones.
   g) She secretes a pheromone 9 hydroxyl decenoic acid.
   h) Old queen does not secrete hormone so it is replaced by transferring one of the recent larvae to queen cell.
   i) Newly emerged queen kills unhatched queens.
   j) Life is about 5 years.

9. **Drones**:
   a) Large wings, robust body, reduced mouth parts, fed by workers.
   b) mate with fertile female (Queen)
   c) Life is very short (starved to death)

10. **Workers:** a) smallest, non-fertile females,
  b) Life is two to four months.
  c) They collect pollen grains and nectar from flowers with the help of **pollen brushes** (present on **tarsus** of legs) & store them in pollen baskets.
  d) **Pollen basket** or **corbicula**, **Pollen press** & **Pollen rake** are present on **tibia of metathoracic** legs.
  e) They attack enemies (protect colony) with a sting present at the tip of abdomen.

These workers are:

i. Laying Worker bee: – Lays unfertilized eggs in the absence of a queen bee that develop into drones.

ii. Nurse workers: – ♦ 1 to 10 days old
  - ♦ Clean the hive.
  - ♦ Serve the queen with royal jelly that contains more mandibu-lar secretion & most larvae.
  - ♦ Serve the drones with honey & bee beard (pollen+honey).

iii. House workers– ♦ 10 to 20 days old.
  - ♦ They perform house cleaning, guarding hive, accepting nectar and pollen for foragers.
  - ♦ They secrete wax through wax glands present on 2^{nd}, 3^{rd}, 4^{th}, & 5^{th} abdominal segments.
  - ♦ They form walls & caps of comb cells (comb building).

iv. Field Workers – 20 days after, till death.
  - ♦ They collect nectar, pollen grains & resins from flowers.
  - ♦ They convert nectar into honey by enzymes in crop.
  - ♦ They deposit honey & pollen grains in storage chamber.
  - ♦ They make **propolis** (a bee glue), from collected resins & tree saps used to seal the cracks in comb.
  - ♦ They perform **round dance** & **waggle dance** to communicate with other bees. (Discovered by Karl Von Frisch-awarded Nobel Prize).

11. Economic Importance:
  i) Honey collected from honey combs contains sugars like levulose, dextrose & maltose.
  ii) Used in manufacture of jellies, jams & cakes.
  iii) Wax is used in making polishes & candles.
  iv) Propolis is used in the treatment of inflammation, superficial burns.
  v) Venom of bee treats arthritis.
  vi) A good antiseptic (applied on wounds).
  vii) Honey bee is a good pollinator.

Animal Husbandry

Fisheries

1. Blue revolution – Capturing & culturing of aquatic organisms.
2. Fishery – Exploitation of fish & other related aquatic organisms.
3. Marine fishery – Capturing of aquatic organisms from seas.

4. Offshore fishery – Capturing of aquatic organisms from open waters of sea.
5. Inshore fishery – Capturing of aquatic organisms from coastal waters.
6. Inland fishery – Capturing of aquatic organisms from fresh water bodies & estuaries.
7. Culture fisheries – Culturing of selected aquatic organisms for better production.
8. Mariculture – Culturing of sea water aquatic organisms.
9. Fresh water aquaculture – Culturing of fresh water aquatic organisms.
10. Pisciculture – Culture of fishes.
11. Prawn /shrimp culture – Culture of prawns/shrimps.
12. Crab culture – Culture of crabs.
13. Oyester culture – Culture of edible or pearl oysters.
14. Sea weed culture – Culture of sea weeds.
15. Fin Fishery – Capturing & culturing of true fishes.
16. Shell fishery – Capturing & culturing of aquatic organisms other than fish. (shrimps & scampy high export value).
17. Head quarters of CMFRI → at Cochin.
18. Central Institute of Fresh water Aquaculture → (CIFA) → at kiasal – yaganga, Orissa.
19. Central Institute of Brackish water Aquaculture (CIBA)– at Chennai.
20. Central Inland Capture Fisheries Research Institute(CICFRI) – at Barackpore, Kolkata.
21. MPEDA → Marine Products Export Development Authority.
22. State Institute of Fishery Technology (SIFT) → at Kakinada, Andhra Pradesh.
23. Essential amino acids in fish meat → methionine & lysine.
24. Shark liver oil → rich in Vit. A.
25. Cod liver oil → rich in Vit D.
26. Omega 3 fatty acid → cholesterol reducing agents in fish meat (oil of sardines & tunas).
27. Cartilagenous fishes → not relished as good food fishes (meat emits urea smell).
28. Fish guano – Solid waste of fish used as fertilizer.
29. Scrap fish – Used for the preparation of fish meal.
30. Shagreen – Skin of sharks → used as abrasive.
31. Craft – Vessels used in fishing.
32. Coracle – Simple craft with circular frame of bamboo.
33. Dugout catamaran – Donga & sangadam.
34. Boats used in both inshore & inland fishing – Catamaran, masula, kakinada, naradhing, padava & theppa.
35. In offshore fishing – Mechanized boats & ships.
36. Traps – Gear used in inland fishing.
37. Darts, spears & barbed heads → used in game fishery.
38. Lines & hooks → used in inland fishery.
39. Cast nets & stake nets → used in inland fishing.
40. Boat seines, inshore seines, drift nets & wall nets → used in inshore fishing.
41. Long lines → used to capture tunas.
42. Gill nets → used to capture oil sardines.
43. Dipnets → used to capture Hilsa in river.
44. Gamcha → used to capture fish spawn.
45. Travel net → used to capture bottom fish with the help of mechanized boats.
46. Stake net → used to catch brackish water fishes.

Poultry

1. Debeaking – Clipping 1/3 of the upper beak in young chickens.
2. First debeaking – 10th day.

3. Second debeaking – 13^{th} to 14^{th} week.
4. Advantage of debeaking – Pecking habit & wastage of food is prevented.
5. Dubbing – Prooning of combs & wattles in birds.
6. Broodiness – Instinct of female bird to brood eggs.
7. Prolapse – Falling down of uterus (containing eggs).
8. Culting – Separation of non-productive, cannibilistic & sick birds from the folk.
9. Deworming – Treatment of sick birds for expulsion of intestinal parasites (every 8 weeks)
10. Various management practices – Hatching, brooding & housing.
11. Duration of chick development in egg – 21 days.
12. Brooding – Rearing of one day old chicks till the 8^{th} week.
13. Artificial brooders – Basket brooders & battery brooders.
14. Chicks mash & brooder mash – Feed given to chicks in brooder.
15. Vaccination – a) One day old chicks → vaccinated against Marek's disease.
b) 16 days old chicks → vaccinated against fowl pox.
c) Six weeks old chicks → booster dose for fowl pox.
17. First deworming – At the age of 8 weeks.
18. Pullet – Young chicken → lay eggs from 17^{th} to 20^{th} weeks.
19. Grower mash – Feed given to pullets.
20. Booster dose for Ranikhet disease. At the age of 8-10 weeks.
21. Pre layer mash – Feed given from 17^{th} to 20^{th} week.
22. Layer mash – Feed given from 21^{st} week onwards.
23. Distance between 2 poultry sheds – 20 m.
24. Stock house → used for growers.
25. Distance between stock house & layer house – 50 to 100 m.
26. Battery system – Most intensive system of poultry farming.
27. Cage fatigue & fatty liver syndrome – A desease in birds of battery system.
28. Thickness of litter on floor of a poultry shed in deep litter system – 8" to 12".
29. Diseases uncommon in deep litter system Coccidiasis & desease due to worm infections.
30. Litter in shed → maintain constant temperature.
31. Feeders used in deep litter system → (a) circular feeders, (b) trough feeders & (c) long feeders.
32. Broiler or fryer – A young chicken (of either sex) of 8 to 10 weeks.
33. Roaster – An older & heavier bird than fryer.
34. Temperature reduced gradually at the rate of 5^0 F from 95^0 F to 70^0 F (during raising of broilers).
35. Floor space required for a broiler in deep litter system → 1.0 to 1.2 square feet.
36. Floor space required for a layer in deep litter system → 1.8 to 2.0 square feet.
37. NECC (National Egg Coordination Committee) – Monitors marketing facilities for poultry products.
38. IVRI (Indian Vetinary Research Institute) – Produces poultry vaccines.
39. NABARD (National Bank for Agriculture and Rural Development)– Provides financial assistance for poultry farming.
40. Legendary person strived for the growth of poultry industry in India → Dr. B.V. Rao.
41. Poultry birds consume 1.9 Kg of feed to form 1.0 Kg of protein.
42. Poultry build up litter contains → N = 3%, P = 2% & K = 2%.
43. Zoological name of fowl – *Gallus domesticus*.
44. American class birds – a) Rhode Island Red, b) Plymouth Rock c) New Hampshire & (d) Wyandotte.
45. Asiatic birds – Brahma & Cochin.
46. English class birds – a) Sussex, b) Australop c) Cornish.

47. Mediterranean class birds – (a) White Leghorn (b) Minorca (c) Ancona.
48. Meat birds – a) Rhode Island Red, b) Cochin, c) Brahma d) Sussex & Cornish.
49. Dual purpose birds – a) Plymouth Rock, b) New flampshire, c) Wyandotte & d) Australop.
50. Egg bird – Ancona.
51. Efficient egg bird – White leghorn.
52. Dam of white leghorn x sire of Rhode Island Red → hybrid layers.
53. Dam of Plymouth Rock or New flampshire X sire of Cornish breed → hybrid broilers.
54. Popular hybrid broiler in India – a) Vencobb, b) Ross & c) Hubbard.
55. Hybrid layers raised in India – a) Babcock, b) flyline & c) flisex.
56. Vitamins present in eggs – A, D & riboflavin.
57. Food value of 100 gm of egg –
    a) Protein = 13.% b) fat = 13.3% c) Energy = 173 K.cal d) Ca = 27mg e) Phosphorus = 102mg.
58. Food value of broiler meat –
    a) Proteins = 20% b) fat 2.5% c) Ca = 14 mg d) P = 200 mg e) Energy = 109 K.cal.
59. Biological value (B.V.) – Percent of N retained by the body for maintenance of growth.
60. Protein efficiency ratio = Weight gain/intake of protein.
61. Egg has highest biological value & protein efficiency ratio.
62. Pre starter mash – Feed given initially to the broiler chicks.
63. Starter mash – Feed given to broilers till 6^{th} week.
64. Finish mash – Feed given to broilers from 7^{th} to 10^{th} week.
65. Ranikhet disease or New castle disease –
    a) Caused by Paramyxovirus.
    b) Highly pathogenic & common at all age groups → causing mass mortality.
    c) First dose against Ranikhet disease → given at 3^{rd} to 5^{th} day.
    d) Booster dose against Ranikhet disease → at 24^{th} to 26^{th} day.
66. Marek's disease – a) Highly infectious disease caused by viruses of Herpes group in fowls.
    b) Symptoms – Enlargement of sciatic nerve, enlargement of glands like spleen.
    c) Target – 2 to 4 month old birds.
67. Gumboro disease or Infectious Bursitis –
    a) Contagious, caused by IBD virus.
    b) Target – 2 to 12 week old chicks.
    c) Symptoms – Loss of appetite, white diarrhoea, enlargement of Bursa of fabricius.
    d) Ist & booster doses in layer birds → at 14^{th} to 16^{th} day & 20^{th} to 26^{th} day.
    e) Ist & booster doses in broilers – at 7^{th} to 9^{th} day & 16^{th} to 18^{th} day.
68. Fowl cholera – a) Caused by *Pasteurella avicida*
    b) Symptoms – Yellow colour droppings, greenish diarrhea, pin point foci in liver, pin point haemorrhage on pericardium &, bluish discolouration of combs.
    c) Medicine – Penicillin & tetracycline.
69. Roup disease – Caused by *Haemophallus gallinarum*.
70. Infectious Coryza – a) Symptoms → Nasal & eye discharge with foul smell & acute respiratory problem.
    b) Medicine → Streptomycin & tetracycline.
71. Chronic Respiratory Disease (CRD) – a) Caused by *Mycoplasma galisepticum*
    b) Transmitted through eggs, nasal discharge & droppings.
    c) Medicine – Erythromycin & tetracyclin.
72. Brooder pneumonia – a) Caused by *Aspergilus fumigatus*
    b) Medicine → copper sulphate
73. Aspergillosis – Symptoms → Congested lungs with nodules & difficulty in breathing.
74. Aflatoxicosis – a) Caused by *Aspergillus flavus*

b) Symptoms – Reduced immunity, & susceptibility to infections.
75. Thrush (Moniliasis) – Caused by *Oidium albicans*
76. Coccidiasis – Caused by *Eimeria tenella*
77. Fungal diseases – Aspergillosis, Aflatoxicosis, Thrush.
78. Bacterial diseases – Fowl cholera, Roup disease & CRD.
79. Viral diseases – Ranikhet, Marecks, & Gumboro disease.

Animal Breeding

1. Improving the genetic merit of livestock population.
2. Selection – In early days man selected superior animals for mating to produce the progeny.
3. Inbreeding – Mating of related individuals within 4 to 6 generations.
   a) Close breeding – Mating of male & female off spring of same pair of parents (mating of male parent to his daughter or a female parent to her son).
   b) Line breeding – mating of related animals (cousin-mating).
4. Advantages of inbreeding – a) Increases homozygosity –
   b) Decreases heterozygosity.
   c) Favours genetic uniformity.
   d) Produces pure strains from unknown stocks.
   e) Desired animals are selected.
   f) Undesired animals are culled.
5. Disadvantages of inbreeding –
   a) Causes inbreeding depression (depression of yield or vigour).
   b) Decreases reproductive efficiency.
   c) Out ward expression of undesired hereditary characters.
6. Out breeding – Breeding of unrelated animals.
   a) Out crossing – Crossing of unrelated pure breeding animals of different traits within same breed (off spring is out cross)
   eg- Rhode Island Red fowl (with single comb) × Rhode Island Red Fowl (with rose comb).
   b) Cross breeding – Mating of animals of different breeds (off spring is cross breed).
   eg- White Leghorn × Rhode Island Red
   c) Species hybridization – Crossing of two different species of a genus (less common in animals).
   eg – i) Jack (male ass) × Mare (female horse) → Mule (sterile)
   ii) Stallion (male horse) × Jennet (female ass) → Hinny (sterile)
   ↓
   Inferior to mule as a work animal
7. Advantages of out crossing & cross breeding -
   a) Highly effective for characters that are under the control of genes (polygenic & cumulative).
   b) Introduces a desirable character in a breed & improves it by grading up
8. Disadvantages of out crossing & cross breeding –
   It requires the maintenance of 2 or more pure breeds.
9. Other methods of Animal breeding –
   a) Artificial Insemination (AI) –
   i) Semen of desired male animal is injected into female reproductive tract.
   ii) Semen is diluted, preserved in frozen condition, transported to distant places for use.
   b) Multiple Ovulation Embryo Transfer Technology (MOET)

i) A cow is administered with gonadotropic hormone (FSH) to induce follicle maturation & super ovulation (produces 6 to 8 secondary oocytes instead one).
ii) This cow is crossed with a desirable male or artificially inseminated.
iii) Fertilized eggs (zygote) at 8 – 32 cell stage are transferred to surrogate mothers.

10. Heterosis – a) A phenomenon in which crossing of unrelated individuals result in the progeny with increased vigour.
b) The off spring has large number of loci with dominant genotypes than either of the parents.

11. Progeny test – The assessment of characters of the parent by studying the characters of its progeny.
eg – Milk yield in cattles.

12. Cloning – a) Production of genes or cells or organisms with identical genetic constitution.
i) Gene cloning – Multiplication of specific gene into several copies by recombinant DNA technology or polymerase chain reaction (PCR)
ii) Cell cloning – Production of specific cell types . e.g. Production of hybridoma cells to produce monoclonal antibodies.
iii) Organism cloning – Production of individual plants or animals with identical genetic constitution.
b) Cloning depends on totipotency of a cell (ability of single cell to divide & develop into complete individual).
c) Totipotent cells – i) Meristematic cells → in plants.
ii) Zygote in animals.
d) Steps in Dolly cloning by Ian Wilmut from U.K.
i) Isolation of udder cell (vegetative or somatic cells – 2n) from Finn Dorset eve (template of Dolly).
ii) Culture of udder cell to produce several cells .
iii) Isolation of an egg cell from a scotitsh blackface eve.
iv) Denucleation of egg.
v) Fusion of udder cell with denucleated egg cell by electrical stimulus → diploid cell.
vi) Fused cell divides repeated by under in vitro conditions (electric stimulus).
vii) Blastocyst formed is implanted in the uterus of a foster or surrogate Scottish black face mother.
viii) Born lamb is genetically & phenotypically indentical to Finn Dorset from which the udder cells were collected.

13. Transgenic Animals–a)The organism in which its own genome contains a part of genome of other animal.
b) Animals with desired traits are produced by transferring the respective gene into other organism.
c) DNA can be introduced into zygotes either by microinjection, or by viral vectors or by direct uptake of DNA stimulated by $CaCl_2$ or by giving an electric current.
d) Gene for growth hormone isolated from rabbit & human beings were tagged to promoter region of a mouse gene.
e) Promoter with gene was ligated to the plasmid vector P^{BR322} to produce recombinant DNA, which was transferred to the zygote of a mouse in vitro.
f) Embryo was implanted in the uterus of a mouse.
g) Transgenic animals are used to produce expensive & rare proteins for "pharming" of drugs.

MICROBES IN HUMAN WELFARE

- Microbes are diverse–protozoa, bacteria, fungi and microscopic plants viruses, viroids and also prions that are proteinacious infectious agents.
- Microbes like bacteria and many fungi can be grown on nutritive media to form, that can be seen with the naked eyes.
- They also cause diseases in animals and plants. But this should not make you think that all microbes are harmful; several microbes are useful to man in diverse ways.

Microbes in house hold

- Micro-organisms such as *Lactobacillus* and others commonly called **lactic acid bacteria (LAB)** grow in milk and convert it to curd.
- A small amount of curd added to the fresh milk as inoculum or starter contain millions of LAB.
- LAB improves nutritional quality by increasing vitamin B12. and also check microbes in stomach.
- A number of traditional drinks and foods are also made by fermentation by the microbes.
- 'Toddy', a traditional drink of some parts of southern India is made by fermenting sap from palms.
- Microbes are also used to ferment fish, soyabean and bambooshoots to make foods.
- Cheese, is one of the oldest food items in which microbes were used.
- Different varieties of cheese are known by their characteristic texture, flavour and taste, the specificity coming from the microbes used.
- 'Swiss cheese' are due to production of a large amount of CO_2 by a bacterium named *Propionibacterium sharmanii*.
- The 'Roquefort cheese' are ripened by growing a specific fungi on them, which gives them a particular flavour.

Microbes In Industrial Products

- Even in industry, microbes are used to synthesise a number of products valuable to human beings.
- Beverages and antibiotics are some examples.Production on an industrial scale, requires growing microbes in very large vessels called **fermentors.**
- Microbes especially yeasts have been used from time immemorial for the production of beverages like wine, beer, whisky, brandy or rum.
- *Saccharomyces cerevisiae* used for bread-making and commonly called brewer's yeast, is used for fermenting malted cereals and fruit juices, to produce ethanol.
- Depending on the type of the raw material used for fermentation and the type of processing different types of alcoholic drinks are obtained.
- Wine and beer are produced without distillation whereas whisky, brandy and rum are produced by distillation of the fermented broth.
- Antibiotics produced by microbes are regarded as one of the most significant discoveries of the twentieth century.
- Antibiotics are chemical substances, which are produced by some microbes and can kill or retard the growth of other microbes.
- Penicillin was the first antibiotic discovered by Alexander Fleming while working on penicillium notatum.
- This antibiotic was extensively used to treat American soldiers wounded in World War II. Fleming, Chain and Florey were awarded the Nobel Prize in 1945, for this discovery.

- Microbes are also used for commercial and industrial production of certain chemicals like organic acids, alcohols and enzymes.
- Examples of acid producers are *Aspergillus niger* (a fungus) of citric acid, *Acetobacteraceti* (a bacterium) of acetic acid; *Clostridium butylicum* (a bacterium) of butyric acid and *Lactobacillus* (a bacterium) of lactic acid.
- Yeast (*Saccharomyces cerevisiae)* is used for commercial production of ethanol.
- Microbes are also used for production of enzymes. Lipases are used in detergent formulations and are helpful in removing oily stainsfrom the laundry.
- Streptokinase produced by the bacterium *Streptococcus* and modified by genetic engineering is used as a 'clot buster' for removing clots from the blood vessels of patients who have undergone myocardial infraction leading to heart attack.
- cyclosporin A is used as an immunosuppressive agent in organ-transplant patients, is produced by the fungus *Trichoderma polysporum*.
- Statins produced by the yeast *Monascus purpureus* have been commercialised as blood-cholesterol lowering agents.It acts by competitively inhibiting the enzyme responsible for synthesis of cholesterol.

Microbes In Sewage Treatment

Treatment of waste water is done by the heterotrophic microbes naturally present in the sewage. This treatment is carried out in two stages:

- **Primary treatment** : These treatment steps basically involve physical removal of particles – large and small – from the sewage through filtration and sedimentation.

Secondary treatment or Biological treatment : The primary effluent is passed into large aeration tanks where it is constantly agitated mechanically and air is pumped into it. It reduces the BOD of effluents.

- sewage is being produced in much larger quantities than ever before.
- So the untreated sewage is often discharged directly into rivers leading to their pollution and increase in water-borne diseases.
- The Ministry of Environment and Forests has initiated **Ganga Action Plan** and **Yamuna Action Plan** to save these major rivers of our country from pollution.

Microbes In Production Of Biogas

- Biogas is a mixture of gases (containing predominantly methane) produced by the microbial activity and which may be used as fuel.
- certain bacteria, which grow anaerobically on cellulosic material, produce large amount of methane along with CO2 and H2. These bacteria are collectively called **methanogens**, and one such common bacterium is *Methanobacterium*.
- The excreta (dung) of cattle, commonly called *gobar*, is rich in these bacteria. Dung can be used for generation of biogas, commonly called *gobar gas*.
- The technology of biogas production was developed in India mainly due to the efforts of Indian Agricultural Research Institute (IARI) and Khadi and Village Industries Commission (KVIC).

Microbes As Biocontrol Agents

- Biocontrol refers to the use of biological methods for controlling plant diseases and pests.
- In modern society, these problems have been tackled increasingly by the use of chemicals – by use of insecticides and pesticides.

- These chemicals are toxic and extremely harmful, to human beings and animals alike, and have been polluting our environment (soil, ground water), fruits, vegetables and crop plants.
- Our soil is also polluted through our use of weedicides to remove weeds.
- The Ladybird, and Dragonflies are useful to get rid of aphids and mosquitoes, respectively.
- An example of microbial biocontrol agents that can be introduced in order to control butterfly caterpillars is the bacteria *Bacillus thuringiensis*.
- fungus *Trichoderma: Trichoderma* species are free-living fungi that are very common in the root ecosystems. They are effective biocontrol agents of several plant pathogens.
- Baculoviruses are pathogens that attack insects and other arthropods.
- The majority of baculoviruses used as biological control agents are in the genus *Nucleopolyhedrovirus.*

Microbes As Biofertilisers

- Soil is the main substratum for growth of plants. It is the source of water & minerals
- Soil containing all the essential elements is called as eutropic soil
- Intensive cultivation of crop plants results in depletion of mineral elements in soil. The soil deficient in some essential elements is known as Oligotrophic soil infertile soil
- Oligotropic soil (infertile soil) can be made into eutropic soil i.e. fertile by adding chemical substances which are known as chemical fertilizers
- Fertilizers increase soil fertility & crop productivity
- Chemical fertilizers played a major role in green revolution
- Application of chemical fertilizers may result in loss of soil fertility, environmental pollution, etc
- To reduce the side effects of chemical fertilizers, biofertilizers are used to increase crop yield

<u>TYPES OF FERTILIZERS</u>: Fertilizers are classified into three different types ----
i) Organic Fertilizers
ii) Inorganic Fertilizers
iii) Biofertilizers

i) <u>Organic Fertilizers</u>: Compost, farm-yard manure, green manure & vermicompost are some important organic fertilizers

- Earthworms convert organic materials into manure
- Rearing of earthworms is known as Vermiculture. The manure produced with the help of earthworms is known as Vermicompost
- Vermicompost contains 18% of carbon, 2-3% nitrogen, 1-2% phosphorous, 1-5% potassium

ii) <u>Inorganic Fertilizers</u>: Nitrogen fertilizers, Phosphorous fertilizers & potassium fertilizers are some important inorganic fertilizers

- Nitrogen fertilizers--- Ex: Urea, Ammonium Sulphate, Calcium ammonium nitrate etc
- Phosphorous fertilizers ---Ex: Super phosphate, Diammonium phosphate (DAP), Rock phosphate, Bone metal etc

- Potassium Phosphate --- Ex: Murate of Potash (Potassium Chloride), sulphate of potash etc

iii) Biofertilizers:

- Biofertilizers are "the active strains of micro-organisms which improves the soil fertility".
- Most of the biofertilizers are nitrogen fixing prokaryotes
  Ex: Rhizobium, Azospirillium, Nostoc Anabena etc
- Some important biofertilizers which increases soil fertility are ----

a) Rhizobium Inoculants:

- Rhizobium is rod-shaped, gram negative, motile bacterium. It lives as symbionat
- Rhizobium inoculants are used to increase the yield of legume crops
- Rhizobium inoculents are applied to legume seeds with gum or carboxy methyle cellulose. The treated seeds are then sown. The plants developed from such seeds develops number of root nodules with better growth & yield

b) Azospirllium:

- It is comma shaped, aerobic motile bacterium. It lives as endosymbiont in cortical cells & protoxylem vessels of wheat, maize, sorghum, barley etc.
- It fixes atmospheric nitrogen & convert it into ammonia. It also secrete growth promoting substances
- Azospirilllium enhances the crop yield in crops like sorghum & pearl mullet
- The method seed-dressing with bacteria like Rhizobium, Azotobacter, Azospirillum etc is known as Bacterization
- Inoculating the seeds with bacteria reduces environmental pollution

c) Cyanobacteria:

- Cyanobacteria or blue green algae like Nostoc & Anabena are used as biofertilizers. The either live freely or in symbiotic association.
- The fix atmospheric nitrogen symbotically or asymbiotically
- In Japan, Blue-green algae (BAG) is used as biofertilizer in rice yield for increasing the yield
- Cyanobacteria inoculants can be prepared in the field by pit method. In this method, a pit is dug & water is poured in the pit. Dry powder of Blue green algae is sprinkled over the water surface. After 7 days BAG inoculants develops as dense mats. These mats are cut into small fragments & are applied to rice field before or after transplantation
- Application of 10kgs of Blue green algae per hectare gives better yield
- The use of Blue green algae in the filed as biofertilizer is known as Algalization Venkataraman (1961) used the term algalization

d) Azolla:

- Azolla is a hydrophyte & is a pteridophyte
- The leaves of Azolla possess mucilage cavities in which Blue green algae Anabena azolle lives as endosymbiont & helps in nitrogen fixation
- It was first used as biofertilizer in Vietnam in 1957
- It adds 30 –40 kgs of nitrogen per hectare
- It is used to increase the yield
- Azolla can be applied by two methods ----

i) incorporation of Azolla in soil before transplantation of rice
ii) after transplantation water is drained & azolla is added to the soil

- Azolla pinnata is tolerant to heavy metals like Hg, Pb, Cd, Cr etc hence it can be used as green manure in rice fields in area polluted with heavy metals.

e) Mycorrhizae:

- The association between fungal hyphae & roots of higher plants is known as mycorrhizae or fungal roots
- Mycorrhizal association is of three types
  i) Ectomycorrhizae
  ii) Endomycorrhizae
  iii) Ectendomycorrhizae

i) Ectomycorrhizae:When fungi is present on the surface of the roots of vascular plants it is known as ectomycorrhizae. Root hairs are absent in these plants & fungal hyphae helps in absorption of water

ii) Endomycorrhizae: When fungal hypae penetrate into the cortex of roots & present in the intecellular spaces they are described as endomycorrhizae

- Endomycorrhizae forms vesicles (i.e. storage structures) & arbuscules (i.e. haustoria) inside the host & hence they are also known as Vescular arbuscular mycorrhizae (VAM) Ex: Glomus VAM increases absorption of phosphate ions
- Application of VAM increases the yield & resistance in crops such as soybeans, red gram, potato, wheat & maize etc
- All endomycorrhizae do not produce arbuscules but produce only vesicles & hence VAM is also known as Arbuscular mycorrhizae (i.e. AM fungai)

iii) Ectendomycorrhizae: When fungai are present on the surface as well as intercellularly in cortex they are described as ectendomycorrhizae

Importance of Biofertilizers:

- Biofertilizers are produced at a cheaper cost that chemical fertilizers & can be used by small farmers. They can develop biofertilizers at their own
- Biofertilizers are eco-friendly & do not cause environmental pollution
- Biofertilizers increase the physical & chemical properties of soil such as soil texture, p^H, water holding capacity etc
- Application of biofertilizers increases the yield by 10 – 45%
- Production of biofertilizers does not require fossil fuels
- Bacterial biofertilizers secretes antibiotics which acts as pesticides
- BAG fertilizers secretes growth promoting substances such as IAA, amino acids, mucilage etc. Mucilage helps information of soil aggregates
- Azolla supplies nitrogen & increase organic matter to the soil. It absorbs heavy metals from soil
- VAM helps in absorption of P, Zn & Cu. They increases resistance of plants

Match the following:

1) The foundation for green revolution were laid by
   1) Knight 2) Cotton Mather 3) Thomas Fairchild 4) Norman E.Borlang
2) Sexuality in plants was discovered by
   1) Cotto mather 2) Joseph Koelreuter 3) Knight 4) Camerarius
3) The first scientist to identify natural hybridization in maize was
   1) Camararius 2) Cotton Mather 3) Joseph Koelreuter 4) Knight

4) The first to produce artificial hybrid was
1) Thomas Fairchild 2) Koelreuter 3) Canurarius 4) Knight
5) New hybrid varieties of tobacco were produced by
1) Camerarius 2) Knight 3) Joseph Koelreuter 4) Thomas Fairchild
6) The first to use hybridization in fruit production was
1) Camerarius 2) Knight 3) Thomas Fair child 4) Joseph Koelreuter
7) The method of plant breeding is dependent on
1) Type of plant 2) Type of economically important product obtained from plant
3) Type of reproduction 4) Type of present plants
8) The simplest and earliest method of crop improvement is
1) Selection2) Mass selection 3) Pure line selection 4) Introduction
9) The new variety can directly be used in agriculture or horticulture in this method of crop improvement
1) Plant introduction 2) Selection 3) Polyploidy breeding 4) Mutation breeding
10) Locate the correctly matched introduced plants

Variety	Crop	Country
A) Ridley	Wheat	Australia
B) Dixies	Wheat	Mexico
C) Sioux	Tomato	America
D) FA 17	Sweet Potato	China

1) I, II, III 2) II, III, IV 3) I, III, IV 4) II & IV
11) The results of mass selection are apparent for short time only because of
1) Environment 2) Homozygostly 3) Mutations 4) Segregation
12) The progeny of single self – pollinated, homozygous plant is
1) Mass selected plant 2) Pure line 3) Clone 4) Poly ploid
13) The time taken to produce a new variety through pure line selection is about
1) 8 years 2) 9 years 3) 10 years 4) 12 years
14) The only method of improving local varieties of self pollinated crops
1) Clonal selection 2) Mass selection 3) Pureline selection 4) Polyploid
15) This method of crop improvement is considered as an art then science
1) Mass selection 2) Pure line selection 3) Clonal selection 4) Mutations
16) The method of crop improvement is considered as more science than art
1) Mass selection 2) Pure line selection 3) Clonal selection 4) Poly ploidy
17) Clonal selection is always done
1) between clones 2) within a clone
3) within local varieties 4) within introduced varieties
18) The advantage of hybridisation over introduction and selection types of crop improvement is
1) improving homozygosity 2) improving heterozygosity
3) making plants disease resistant 4) incorporation of new characters
19) The synthetic crop plant of Proaceae is
1) Raphanobrassica 2) Bromato 3) Red plum variety 4) Triticale
20) The first synthetic genus is
a. Raphano brassica between 2 members of Brassicaceae
b. Triticale between 2 members of Poaceae
c. Red plum between 2 members of Solanaceae
d. P1 94587 between 2 members of Brassicacea
21) Emasculation is not needed for
A) Bisexual flowers B) Unisexual flowers C) Male sterile lines
1) A & B 2) B & C 3) A & C 4) C alone
22) Emasculation is carried out on

a. Flowers of male sterile plants
b. Male flowers of Dioecious plants
c. Unisexual flowers of polygamous plants
d. Bisexual flowers of female parents

23) The first to observe hybrid vigous was
1) Knight 2) G.H.shull 3) Koel reuter 4) Thomas Fair child
24) The term heterosis was coined by
1) G.H.Shull 2) Joseph Koelreuter 3) Knight 4) Thomas Fair child
25) A cross between in bred (AxB) and inbred (CxD) is
1) Single cross 2) Double cross 3) Triple cross 4) Multiple cross
26) Selfing is done for how many generations to develop inbreeding depression in heterosis experiments?
1) 5 –7 2) 7 –10 3) 2 –5 4) 4 –6
27) The term mutations was coined by
1) Stadler 2) H.J.Muller 3) Karpecheno 4) Hugo de Varies
28) Mutations were induced mutations for the first time in this plant
1) L.J.Stadler 2) H.J.Muller 3) Karpecheno 4) Hugo de Vries
29) L.J.Stadler induced mutations for the first time in this plant
1) Wheat 2) Rice 3) Mango 4) Barley
30) Variations in large numbers are induced in relatively short period by
1) Polyploidy 2) Mutations 3) Hybridization 4) Introduction
31) The polyploids that are generally sterile are
1) 2n 2) 3n 3) 4n 4) 6n
32) 4n female x 2n male will give
1) 6n fertile variety 2) 3n series variety
3) 4n fertile variety 4) 5n series variety
33) Seedless variety of Citrullus vulgaris was produced by
1) 4n x 2n plants 2) 4n x 2n plants 3) 4n x 2n gametes 4) 2n + 6n plants
34) TV 29 is an example of
1) 4n 2) 2n 3) 6n 4) 3n
35) A 2n plant treated with colchicine results in
1) 4n plants 2) 8n plants 3) 6n plants 4) n plants
36) Trifolium alexandrium is
a. first polyploid fodder variety developed in India
b. first synthetic genus of crop plant produced by IARI
c. first pulse variety developed through mutation breeding
d. first synthetic genus that produces latex
37) White cotton is a cross between
1) g.hirsutum x G.arboreum 2) G.hirsutum x G.herbaceum
3) G.hirsutum x G.barbadense 4) 1 & 2
38) Sugandha variety of vetivar is an example of
1) Allo tetraploid 2) Amphidiploid 3) Auto tetra ploid 4) Allo hexaploid
39) Application of acenapthene and coumarin on floral buds and vegetative buds result in
1) Mutations 2) Polyploid 3) Genetic disorders 4) Clone formation
40) Seed fertility is less in this type of crop improvement
1) Polyploidy 2) Mutation 3) Pure line selection 4) Hybridization
41) Oldest known method of crop improvement is one that is
I) practised by farmers II) used for cross pollinated plants
III) successful when more variations are present in the pollination

IV) used to introduce new characters not present in the pollination
1) except I 2) except II 3) except III 4) except IV

42) The disadvantage in mass selection is
1) hybrid vigour 2) acclimatizing ability
3) short lived nature of selected characters 4) heterozygosity

43) Method of plant selection practiced by farmers regularity is
1) pureline selection 2) mass selection
3) hybridization 4) mutations

44) Genotypic and phenotypic similarity (homozygous) is always seen in
1) purelines 2) clones 3) hybrids 4) heterosis

45) A plant breeding method that may cause loss of vigour if continued for longer periods is
1) heterosis 2) hybridisation 3) mass selection 4) pureline selection

46) A cross between two inbred lines of maize is
I) Inter varietel II) Intravarietal III) Single cross IV) Double cross
1) I & II 2) II & IV 3) III & IV 4) I & IV

47) The difference between a cross between 2 inbreed lines of maize in intravarietal cross and single cross is
a. in the first no inbreeding and in the second inbreeding till depression is shown
b. in the first inbreeding and in the second inbreeding without depression
c. in both inbreeding is carried out till inbreeding depression appears
d. the first is heterozygous and the second is homozygous

48) Amplidiploid among the following is
I) G.hirsutum x G.arboreum $\rightarrow$ Deviraj
II) G.hirsutum x G.herbaceum phenolic treatment $\rightarrow$ Deviraj
III) G.hirsutum x G.barbadensephenolic treatment$\rightarrow$ white cotton
IV) N.tabacum x N.rustica $\rightarrow$tobacco
1) I & II 2) II & III 3) III & IV 4) II & IV

49) This crop improvement method may give undesirable results
1) introduction 2) mass selection 3) hybridizaion 4) mutations

50) Bagging in hybridization is carried out
a. before and after artificial pollination on male plant
b. before and after artificial pollination on female plant
c. before and after artificial pollination and after artificial pollination
d. once after artificial pollination

51) The influorescence of bisexual flowers is dipped into hot water for 1 – 10 minutes, the water is at
1) 40 –50^0C 2) 50 –60^0C 3) 55 –60^0C 4) 75 –80^0C

52) Emasculation is carried out on
I) male flowers of monoecious plants
II) Female flowers of diosious plants
III) Bisexual flowers of male sterile lines
IV) Bisexual flowers
1) I & II 2) II & III 3) IV only 4) III only

53) New crop variety with variations is possible in
1) Clonal selection 2) Pureline selection
3) Mass selection 4) Hybridization

54) The reason for heterosis is
I) more dominant genes in the hybrid II) Heterozygosity
III) Inbreeding depression

1) except I 2) except II 3) except III 4) except I & II

55) The first scientist and organism subjected to induced mutations is
1) Karpechenko – rephanobrassica 2) H.J.Muller – Barley
3) H.J.Muller – Drosophila 4) L.J.Standler - Drosophila

56) Triploids are generally sterile due to
a. two genomes being homologous chromosomes
b. one genomes without homologous chromosomes
c. all 4 genomes without homologous chromosomes
d. all 5 genomes without homologous chromosomes

57) 3n condition is not seen in this plant
1) TV29 2) musa 3) watermelon 4) A trifolium

58) AABDD of T.aestivum is
1) 21 2) 28 3) 46 4) 42

59) Substance that can induce polyploidy as well as mutations
1) malic hybradize 2) colchicine
3) mustard gas 4) ultra violet rays

60) Match the following lists:

List –I Scienties	List –II Contribution to Crop improvement
A) Cotton Mather B) Thomas Fair child C) Joseph Koelreuter D) Knight	1) Production of first artificial hybrid 2) Artificial hybridisation in fruit hybrid 3) Dwarf mexican hybrid wheat 4) Production of hybrids of tobacco 5) Identifying natural hybridisation in Maize

1) A-3, B-4, C-4, D-2 2) A-5, B-1, C-4, D-2
3) A-1, B-3, C-5, D-2 4) A-4, B-3, C-2, D-1

61) Match the following lists:

List –I Method	List –II Detail
A) Introduction B) Selection C) Mass selection D) Clonal selection E) Hybridization	1) Fastest & Easiest method 2) No sexual reproduction 3) Mode of reproduction has no relation 4) Only way of introducing new traits 5) Basis of all crop improvement

1) A-4, B-2, C-5, D-1 2) A-5, B-1, C-3, D-2, E-4
3) A-2, B-4, C-3, D-5, E-1 4) A-3, B-5, C-1, D-2, E-4

62) Locate the correct among the following

Variety	Botanical name	Country form which introduced
1) Sonora 64 2) Texas 21 3) Sioux 4) FA17 5) Tachung Native I	Triticum Zea mays Lycopers-icorn Ipomea botatus Oryza sativa	Philippiness America America China Mexico

1) I & III 2) III, IV, V 3) I, III, V 4) II, III, IV

63) Arrange the steps in hybridization
A) Bragging B) Artificial cross pollination c) Emasculation
D) Selection of parents E) Trails and multiplication

1) EDCBA 2) DCABE 3) DAEBC 4) ACEBD

64) The selected parents in hybridization are self pollinated repeatedly for several generation. This is to increase
1) Heterozygosity 2) Homozygosity 3) Polyploidy 4) Mutations

65) A basal medium contains
1) auxins and cytokinis 2) Cytokinins and vitamins
3) gibberellins & sugars 4) Only nutrients

66) A rooting medium consists of
1) no auxins 2) no cytokinins
3) higher content of auxins 4) higher content of cytokinins

67) Seeds to be used as explants are surface sterilised by
1) sodium aligates 2) mercuric chloride
3) sodium hypochlorite 4) ferrous sulphate

68) First plant produced in anther culture is
1) Nicotina 2) Datura innoxa 3) Raphanus 4) Linum

69) Cryopreservation is carried out at
1) -196^0C 2) -400^0C 3) -100^0C 4) 96^0C

70) Synthetic seeds contain
1) callus seeds alignate 2) explant + sodium alignate
3) somatic embryo + sodium alignate 4) explant + soilrite

71) Morchella is a
1) Medicinal plant 2) Morel 3) Pathogen 4) Autotroph

72) Fly agaric is
1) Lentinus edodes 2) Armellarina mellae
3) Amanita muscaria 4) Auricularia

73) Agaricus bisporous can be grown on organic media like wastes because it is a
1) symbiont 2) pathogen 3) autotroph 4) saprophyte

74) The cap of Agaricus is
1) stalk 2) hymenium 3) gills 4) pileus

75) Assertion: Mushrooms are grown on compost
Reason: Mushrooms are saprophytes
a. A and Rare true, R is the correct explanation of A
b. A and R are true, R is not the correct explanation of A
c. A is true but R is false
d. A is false but R is true

76) Assertion: Agaricus bisporous contains amotoxins
Reason: Some fungi produce mycotoxins
a. A and R are true, R is the correct explanation of A
b. A and R are true, R is not the correct explanation of A
c. A is true but R is false
d. A is false but R is true

77) Assertion: Vegetative cells of plants are totipotent
Reason: The genome is same in zygote and vegetative cells
a. A and R are true, R is the correct explanation of A
b. A and R are true, R is not the correct explanation of A
c. A is true but R is false
d. A is false but R is true

78) Assertion: Plants developed from pollen grains are diploid
Reason: Development of plants from pollen grains is called and orgenesis
a. A and R are true, R is the correct explanation of A

b. A and R are true, R is not the correct explanation of A
c. A is true but R is false
d. A is false but R is true

79) Aseptic conditions are essential for inoculation because
a. spores of microorgansisms contaminate the culture medium
b. the cut organs are not infected
c. excised cells are not infected
d. air flow is less in laminar air flow chamber

80) Incubation is carried out for
1) 1 –2 weeks 2) 2 –3 weeks 3) 4 –5 weeks 4) 3 –4 weeks

81) The explant produces callus in
1) basal medium 2) auxin rich medium
3) cytokininrich medium 4) gibberellin rich medium

82) The ratio of auxins: cytokinins is 1:2 in culture medium 'A' and 2:1 in culture medium 'B' what happens if callus is first placed in A and then in B
a. rhizogenesis & caulogenesis respectively
b. caulogenesis & rhizogenesis respectively
c. callus remains as it is
d. somatic embryoids are formed

83) Embryoids are products of
1) sexual reproduction 2) invitro culture
3) caulogeneris 4) organogenesis

84) Locate the true statement
I) higher auxin concentration with other phytohormones promotes rhizogenesis
II) higher gibberellin concentration with other phytohormones promotes caulogenesis
III) higher concentration of cytokinins with other phytohormones promote caulogenesis
IV) without callus embryogenesis may take place
1) I, II, IV 2) I, III, IV 3) I, II,III 4) II, III, IV

85) Tissue culture is based on
1) Cellular totipotency 2) hormonal induction
3) supply of nutrients 4) homozygous condition

86) Arrange the steps in tissue culture in proper order
A) Incubation B) Incubation
C) Sterilizing culture media 4) Acclimatization
1) DCBA 2) CABD 3) CBAD 4) ACBD

87) Nutrient media is essential in tissue culture because
1) cells are grown artificially 2) cells are separated
3) organs are exised 4) soil is available to them

88) The p^H of nutrient medium is
1) highly alkaline 2) highly basic 3) slightly acidic 4) neutral

89) Murashige & Skoog are associated with
1) hydrophonics 2) aerophonics 3) tissue culture 4) embryology

90) This explant can grow into somatic embryoids on a basal medium also
1) pollen grains 2) uniripe ovules 3) anthers 4) cut parts of embryos

91) NAA, IAA and 2, 4-D are
1) Gibberellins 2) Cytokinins 3) Domins 4) Auxins

92) Benzylamine is a
1) growth inhibitor 2) cytokinin 3) auxin 4) gaseous growth regulator

93) Somatic embryoids are encapsulated with

1) 2, 4-D 2) NAA3) sodium alginate 4) sodium hypochlorite

94) Synthetic seeds
   a. Easily germinate & grow in natural conditions
   b. Easily dessicate if exposed to environment
   c. Need soil rite as food
   d. Grow out of polythene bags

95) The plants from synthetic seeds are covered with polythene bags to prevent
1) respiration 2) sunstroke 3) direct light 4) dessication

96) The acclimatization of seedlings from synthetic seeds is carried out for about
1) 14 days 2) 3 months 3) 2 months 4) 2 days

97) The advantage of haploid plants is
I) Recessive mutations can be studied
II) New genotypes can be produced
III) In genetic engineering
1) I & II 2) II & III 3) I, II 4) I, II, III

98) Embryo culture was first obtained from and by
1) Raphanus – Laibach 2) Nlcotiana – Nitsch
3) Datura innoxa – Maheswari 4) Raphanus – Hanning

99) Embryo rescue of interspecific cross was first carried out in and by
1) Raphanus – Hanning 2) Linum – Laibach
3) Tobacco – Nitsch 4) Datura innoxa – Guha

100) Mass production of plants in tissue culture is called
1) molecular farming 2) cryo preservation
3) bioreactors 4) micro propogation

Keys

1)4	2)4	3)2	4)1	5)3	6)2	7)3	8)4	9)1	10)3
11)4	12)2	13)3	14)3	15)1	16)2	17)1	18)4	19)4	20)1
21)2	22)4	23)3	24)1	25)2	26)1	27)4	28)2	29)4	30)2
31)2	32)2	33)1	34)4	35)1	36)2	37)3	38)3	39)2	40)1
41)4	42)3	43)2	44)1	45)4	46)2	47)1	48)3	49)4	50)2
51)1	52)3	53)4	54)3	55)3	56)2	57)4	58)4	59)2	60)2
61)4	62)4	63)2	64)2	65)4	66)3	67)2	68)2	69)1	70)3
71)2	72)3	73)4	74)4	75)1	76)4	77)1	78)4	79)1	80)4
81)1	82)1	83)2	84)2	85)1	86)2	87)1	88)3	89)3	90)4
91)4	92)2	93)3	94)2	95)4	96)1	97)4	98)4	99)2	100)4

1. Read the following statements and answer the question.
   (i) Gynoecium is situated in the centre, and other parts of the flower are located on the rim of the thalamus almost at the same level.
   (ii) Ovary is half-inferior.
   (iii) Examples are plum, rose and peach. Which condition of flowers is being described by the above statements ?
   (a) hypogyny (b) Perigyny (c) epigyny (d) none of these
2. In syngenesious androecium
   (1) Anthers are free while filaments are fused
   (2) Anthers as well as filaments both are free
   (3) Stamens are fused by anthers while filaments are free
   (4) Stamens are fused by both filaments as well as anther
3. Find correct match

Column-I	Column-II
a. Spikelet	(i) Involucre
b. Capitulum	(ii) Spathe
c. Hypanthodium	(iii) Glume
d. Spadix	(iv) Gall flower

   (1) a(iii), b(i), c(iv), d(ii) (2) a(iii), b(i), c(ii), d(iv)
   (3) a(iv), b(iii), c(ii), d(i) (4) a(i), b(iii), c(iv), d(ii)
4. Catkin inflorescence is found in :-
   (1) Wheat (2) Oat (3) Mulberry (4) Fig
5. Which is the odd type of vegetable in a basket containing the following ?
   (1) Radishes (2) Carrots (3) Potatoes (4) Beet roots
6. Find correct match

Column-l	Column-ll
a. Tetradynamous	(1) Papilionaceae
b. Diadelphous	(2) Brassicaceae
c. Syngenesious	(3) Liliaceae
d. Epiphyllous	(4) Asteraceae

   (1) a(ii), b(i), c(iv), d(iii) (2) a(i), b(ii), c(iv), d(iii)
   (3) a(iii), b(iv), c(i), d(ii) (4) a(ii), b(ii), c(iii), d(iv)
7. Basal placentation in monocarpellary ovary is found in:
   (1) Asteraceae (2) Fabaceae (3) Poaceae (4) Liliceae
8. Which of the following can be regarded as equivalent to perianth?
   (1) Glumes (2) Lodicules (3) Palea (4) Lemma
9. Versatile anthers are present in
   (1) Cycas (2) cotton (3) Jowar (4) Brassica
10. Which of these characters do not belongs to Compositae?
   (1) Ligulate ray florets (2) Basal ovule
   (3) Syngenesious stamens (4) Pentafid stigma
11. Cruciferous plants when crushed emit a pungent smell, It is due to the presence of:-
   (1) Oxalic acid (2) Alkaloids
   (3) Iron compounds (4) Sulphur compounds
12. Turnip (Brassica rapa) belongs to family:-
   (1) Cruciferae (2) Malvaceae (3) Liliaceae (4) Cucurbitaceae
13. Aestivation of petals in family Malvaceae is:-
   (1) Valvate (2) Imbricate (3) Twisted (4) Vexillary

14. Shoe flower belongs to :-
(1) Solanaceae (2) Malvaceae (3) Papilionatae (4) Liliaceae

15. A student collected 2 branches of Mustard, 3 branches of Calotropis and Hibiscus, then calculate the number of leaves in those branches (Each branch with 5 nodes)
(1) 100 (2)75 (3) 755 (4) 65

16. The technical term used for the androecium in a flower of China rose (Hibiscus rosasinensis) is
(1) Polyadelphous (2) Monadelphous (3) Diadelphous (4) Polyandrous

17 Lady's finger belongs to the family
(1) Malvaceae (2) Cucurbitaceae (3) Liliaceae (4) Brassicaceae

18. Replum develops in ovary of:
(1) Solanaceae (2) Brassicaceae (3) Asteraceaez (4) None of these

19. Versatile anthers are found in:
(1) Fabaceae (2) Brassicaceae (3) Poaceae (4) Liliaceae

20. Bean seed is an example of
(1) Albuminous seed (2) Exalbuminous seed
(3) Oil yielding seeds (4) None of these

21. In capitulum, the flowers are arranged in:
(1) Centripetal order (2) Basipetal order
(3) Mixed order (4) No definite order

22. Utilocular and bicarpellary ovary of epigynous flower is found in:
(1) Asteraceae (2) Basipetal order (3) Fabaceae (4) Brassieaeae

23. Basal placentation develops when the ovary has:
(1) Single ovule (2) Many ovules
(3) Many locules (4) Single ovule in each locule

24. Cypsella fruit is product of:
(1) Monocarpellary ovary (2) Superior ovary
(3) Bicarpellary ovary (4) Polycarpellary ovary

25. When stamens are united by their anthers, the condition is known as:
(1) Syndrous (2) Syngenesious (3) (4) Monoadelphous

26. In Gramineae/Poaceae, the inflorescence is
(1) spikelet (2) spadix (3) cyathium (4) corymb

27. Glumes occur in:
(1) Spikes (2) Spikelets of spike (3) Corymb (4) Umbel

28. Plant with 4 sepals. 4 petals, 6 stamens, two outer short four inner long. ovary one-celled later becoming two celled belongs to the family
(1) Compositae (2) Gramineae (3) Cruciferae (4) Papaveraceae

29. Corolla is cruciform in case of
(1) Brassicaceae (2) Asteraceae (3) Apiaceae (4) Lamiaceae

30. The given formula belongs to Bre $\oplus$ ⚥ $Epi_3\ K_{(5)}\ C_5\ A_{(\infty)}\ \underline{G_{(5)}}$
(1) Solanaceae (2) Malvaceae (3) Gramineae (4) Compositae

31. Anthers are monothecous in:
(1) Malvaceae (2) Fabaceae (3) Mimosoideae (4) Liliaceae

32. Leguminous crops are agriculturally important as they:
(1) Control pastes (2) Make soil alkaline
(3) Enrich soil with nitrogen (4) Enrich soil with humus

33. How many plants in the list given below have marginal placentation?
Sunheimp, 'Chilli, Colchicum, Onion, Mong, Pea, Tobacco, Lupin, Red gram, Asparagus, Tulip, Mustard
(1) Four (2) Three (3) Six s(4) Five

34. Which of the following is the character of family-Asteraceae?
(1) Head or capitulum inflorescence (2) Syngenesious stamens
(3) Cypsella fruit (4) All the above

35. Hairs or pappus in florets of Asteraceae are modified:
(1) Involucre of bracts (2) Calyx (3) Corolla (4) Thalamus

36. .... is present in the flowers of :-
(1) Banana (2) Rice (3) Marigold (4) Sunflower

37. In Citrus, Duranta and Bougainvillea, the thoms are the modified
(1) axillary buds (2) leaves (3) roots (4) apical bud

38. Leaves of Utricularia are modified into
(1) hooks (2) tendrils (3) bladders (4) pitchers

39. The inflorescence where flowers arise from a common point, is known as
(1) umbel (2) corymb (3) spike (4) spadix

40. The inflorescence in Coriandrum is
(1) panicle (2) capitulum (3) cyme (4) compound umbel

41. Which one of the following statement is correct?
(1) Warm and moist environment favour decomposition whereas low temperature and anaerobiosis inhibit decomposition
(2) Warm and moist environment inhibit decomposition whereas low temperature and anaerobiosis favour decomposition
(3) Warm and anaerobiosis favour decomposition whereas low temperature favours decomposition
(4) Warm and low temperature inhibit decomposition whereas anaerobiosis favours decomposition

42. In a food chain producers form the
(1) first trophic level (2) second trophic level
(3) last trophic level (4) None of these

43. Primary consumers are
(1) autotrophs (2) carnivores (3) Herbivores (4) omnivores